The American Midland Naturalist

Devoted to Natural History,

Primarily that of the Prairie States

Founded by J. A. Nieuwland, C. S. C.

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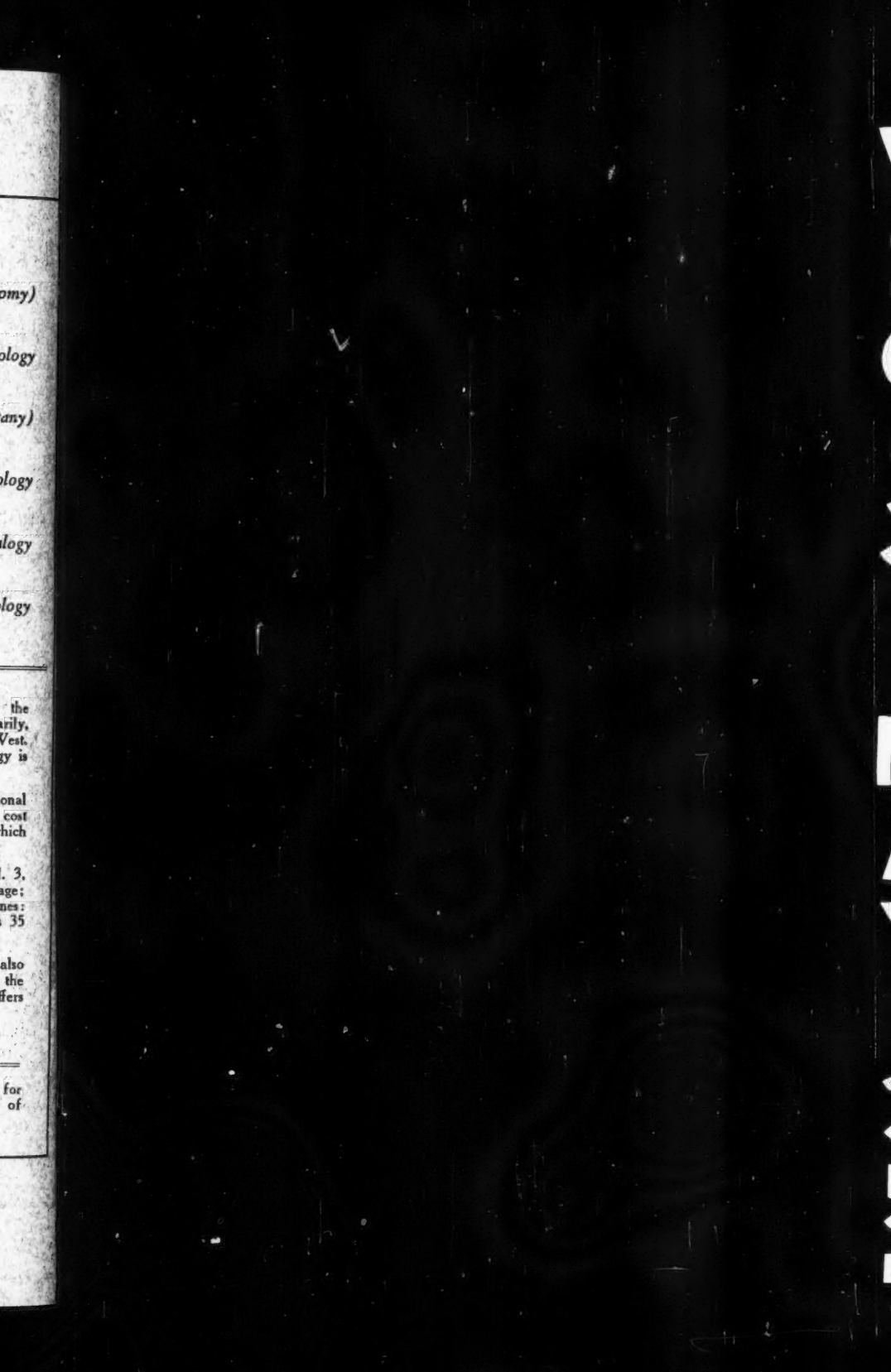

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The American Midland Naturalist

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VOL. 16 MAY, 1935 No. 3

LAND AND FRESHWATER MOLLUSCA FROM NORTH STAR LAKE AND VICINITY, ITASCA COUNTY, MINNESOTA *

A Systematic and Ecologic Study

FRANK COLLINS BAKER

Introduction

The molluscan fauna of the state of Minnesota is probably the least understood of any of the northern states of the Union. Abounding in lakes and streams of all sizes and with many miles of forested area it forms an ideal country for the development of a large and varied fauna. The faunal papers on this state numbers less than a dozen but these are sufficient to give an inkling of the rich fauna awaiting exploration. During the month of August, 1933, the writer spent several weeks at Camp Idlewild on North Star Lake and made somewhat exhaustive collections of both land and freshwater mollusks.

North Star Lake lies in Itasca County in the northern part of the state about 100 miles west of Lake Superior and 60 miles south of the international boundary. There are two main drainage areas in the county, northward by way of Big Fork River into Rainy River and thence to Hudson Bay, and southward into the Mississippi River. The continental divide is near the center of the county. North Star Lake drains into Big Fork River.

The topography of the county is gently rolling with lakes, swamps and bogs in the lowlands and mesophytic forests covering the uplands. East of North Star Lake the country is sharply rolling, the hills (morainic) steep-sided and of considerable elevation. The county is deeply covered with glacial deposits varying from 20 to 100 feet in depth. These consist of moraines, till plains and outwash gravels. Three glacial sheets were deposited in Itasca County, the Nebraskan, the Kansan, and the Wisconsin. The first two are covered by the last till sheet which has given the county its topography.

Lakes abound in Itasca County, approximately 540 are ploted on the county map. They cover about 225 square miles of the 2780 square miles of the county. They range in size from small pools half a mile in diameter to such large bodies of water as Bow String and Winnebigoshish, the latter

* Contribution from the Museum of Natural History, University of Illinois, No. 74.

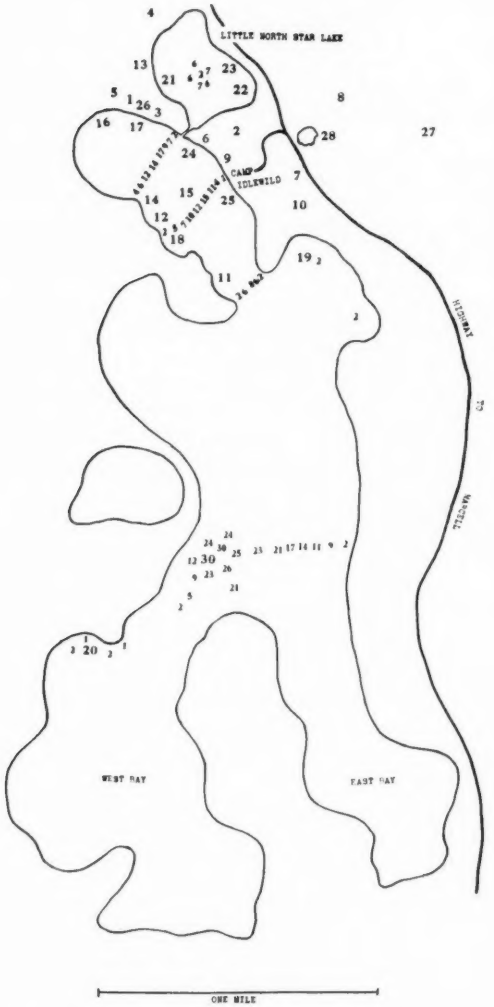

Fig. 1. Sketch Map of North Star Lake and vicinity. The large figures indicate collecting stations; the small figures depths of the lake in meters.

with a diameter of 11 miles and an approximate area of 80 square miles. Some of the lakes are deep, others very shallow.

The region surrounding North Star Lake has been extensively lumbered and in many places a second growth has become well established. About this and other lakes on the higher lands there is a climax forest of the fir-basswood community type, consisting of balsam fir *(Abies balsamea)*, basswood *(Tilia americana)* red oak *(Quercus borealis)*, yellow birch *(Betula lutea)*, white spruce *(Picea glauca)*, hard maple *(Acer saccharum)*, ironwood *(Ostrya virginiana)*, and two pines *(Pinus resinosa* and *P. strobus)*. In the lowlands surrounding the lake and in the adjacent swamps such trees as black spruce *(Picea mariana)*, tamarack *(Larix laricina)*, and cedar *(Thuja occidentalis)* abound. There is everywhere an abundant growth of small shrubs and of seasonal wild flowers.

North Star Lake is about three miles long and somewhat less than a mile wide. The short line is irregular and the lake abounds in small bays. The shores vary from sand and gravel, mostly on points, to mud and silt, the mud in many places becoming deep bogs. Vegetation lines the shores in most places and consists of *Typha, Equisetum, Sparganium, Eleocharis, Scirpus, Sagittaria,* etc. The forest in most cases extends to the edge of the shore. On the east side the land rises rapidly toward the upland area but on the west and south sides swampy conditions prevail. The shallow area bordering the shore extends only a few feet into the lake where the depth rapidly increases. This shallow area supports an abundant vegetation consisting of *Scirpus, Potamogeton* (several species), *Vallisneria spiralis, Lemna Nymphaea, Castalia, Myriophyllum, Chara, Nitella,* etc.

The lake is one of the deep glacial lakes so abundant in the north, the shallow shores descending rapidly from two meters to depths of 14 to 25 meters. The deepest part of the lake was found south of the middle near the west shore where a hole 30 meters in depth occurred. The sketch map indicates the distribution of some of these depths (Fig. 1). The general topography surrounding the lake indicates that North Star Lake was at one time considerably larger than at present and included as a bay Little North Star Lake at the north end as well as several smaller lakes bordering the west and south sides. The falling of the lake level, due to evaporation probably, uncovered shallow bars causing the formation of smaller lakes adjacent to the larger water body. The west bay of North Star Lake will in time form a separate lake, due to the filling of the narrow connection with vegetation and silt (see sketch map, station 20).

Molluscan life in this lake is largely within the 6-foot (2 m.) contour and practically ceases at the 12-foot (4 m.) contour. This vertical distribution of animal life has been noted in almost all lakes studied and is controlled by the shore vegetation for mollusks are absolutely dependent upon plants for their food. In the deeper parts of the lake the only animal life observed was chironomid larvae and an occasional *Pisidium*. In the deepest part of the lake only chironomid larvae were collected. An extensive marl bed lines the shore of Little North Star Lake occurring beneath about three feet of peat

and bog. The marl is of unknown depth and doubtless belongs to the time of greater expansion of the lake, probably in late Wisconsin time. One species, *Gyraulus altissimus,* a common Pleistocene fossil, was found only in this marl bed associated with species still living in the two lakes.

ACKNOWLEDGEMENTS

I am indebted to Dr. Henry A. Pilsbry, of the Academy of Natural Sciences of Philadelphia for assistance in working up Planorbula and to Dr. William J. Clench, of the Museum of Comparative Zoology, for the identifications of Physa. I wish also to acknowledge the many courtesies and helpful assistance extended by Mr. W. A. Stickler, proprietor of Camp Idlewild. To my wife, Mrs. Lillian M. Baker, now deceased, I am indebted for assistance in collecting the material.

ECOLOGICAL CONDITIONS AFFECTING ANIMAL LIFE

Collecting stations were established at different places and more or less extensive notes made of the conditions of the environment. Such studies are of value in helping to interpret the ecological conditions under which the faunas lived during the Pleistocene period, especially as affecting the terrestrial faunas. It is believed by the writer that many of the fossil faunas of the Illinois Pleistocene, especially in the loess deposits, lived under conditions comparable to those now found in northern Minnesota and southern Canada. For this reason, as well as for the general ecologic information, more or less extensive notes on collection stations are of value. Also, associations of species are brought out in this way which are not indicated in a purely systematic list. Again this is of value in the interpretation of Pleistocene faunas. In this paper 44 species and races of aquatic and 18 species and races of land species are enumerated or a total of 62 species and races.

Collecting Stations for Terrestrial Mollusca

Station 1.—North end of North Star Lake above Camp Idlewild. Forest of pine, spruce, hemlock, maple, white cedar or arbor vitae, balsam fir, aspen, birch, all mostly second growth. The forest floor includes the club moss and ground pine, two-leaved Solomon's seal *(Maianthemum), Clintonia,* several violets, several species of golden rod and aster. The ground cover changes with the season and is doubtless rich in wild flowers in the spring. The soil consists of a deep covering of forest debris, leaves, twigs, mold with here and there a patch of moss. Mollusks may be found in this debris, under rotting logs and at the base of rotting stumps of trees. Under the mat of forest debris the following species were collected.

Discus cronkhitei anthonyi	*Euconulus fulvus*
Retinella binneyana	*Cochlicopa lubrica*
Zonitoides arboreus	*Strobilops labyrinthica*

Station 2. (Fig. 2).—Woods bordering south end of Little North Star Lake. Low land, wet in spring and early summer, dry in the fall. Forest of birch, aspen, maple, cedar, fir, hemlock. Forest floor with little vegetation but covered with mat of leaves and debris. Many fallen tree trunks and old

stumps. Mollusks abundant in the debris of the forest floor, under started bark, and about old stumps. Land snails were always rare or absent from cedar stumps or logs but common to abundant in or under birch logs and stumps. Seven species obtained at this station.

Fig. 2. Station 2. Lowland woods north of Camp Idlewild.

Discus cronkhitei anthonyi
Helicodiscus parallelus
Zonitoides arboreus
Retinella binneyana
Euconulus fulvus
Strobilops labyrinthica
Vallonia gracilicosta

Station 3.—Hillside woodland north of Camp Idlewild, between North Star Lake and Little North Star Lake. Forest as in Station 1. Mollusks collected from forest floor in debris. The largest number of land mollusks was found at this station.

Discus cronkhitei anthonyi
Zonitoides arboreus
Retinella binneyana
Hawaiia minuscula
Striatura milium
Vitrina limpida
Gastrocopta tappaniana
Vertigo ventricosa
Strobilops labyrinthica
Cochlicopa lubrica
Succinea ovalis
Carychium exile canadense

Station 4.—Low, marshy woods north of Little North Star Lake. Forest of birch, cedar, tamarack; ostrich ferns, nodding trillium, horsetail, most abundant ground vegetation at edge of forest. Forest itself dark with little or no ground vegetation but with many logs and stumps. The ground is very uneven, filled with deep holes, largely the root cavity of fallen trees. Mollusks abundant under started bark, under wet pieces of bark or wood and under debris.

Anguispira alternata
Discus cronkhitei anthonyi
Helicodiscus parallelus
Zonitoides arboreus
Retinella binneyana
Euconulus fulvus
Gastrocopta tappaniana
Vertigo ventricosa
Strobilops labyrinthica
Cochlicopa lubrica
Carychium exile canadense

Station 5.—Same location as station 1. Mollusks under rotting stumps of birch.

Discus cronkhitei anthonyi
Helicodiscus parallelus
Zonitoides arboreus
Retinella binneyana
Euconulus fulvus
Cochlicopa lubrica
Strobilops labyrinthica
Vallonia gracilicosta
Carychium exile canadense

Stations 6 and 9.—Shore of North Star Lake at Camp Idlewild. Grass-covered shore about three feet above water line. Mollusks on pieces of bark and wood.

Succinea retusa
Zonitoides arboreus
Strobilops labyrinthica.

Stations 7 and 10.—Rolling, hilly woodland south of Camp Idlewild, morainic in character, high ground interspersed with low areas mostly bordering the lake. Forest (of upland) of pine, spruce, cedar, hemlock, aspen, birch, maple, basswood. Ground cover (in August) of asters, several species of ferns, golden rod, several species of violet, jewel weed, and, rarely, nodding trillium. Ground material of forest debris. Mollusks found under logs and in forest debris. Quite abundant.

Discus cronkhitei anthonyi
Helicodiscus parallelus
Planogyra asteriscus
Zonitoides arboreus
Retinella binneyana
Euconulus fulvus
Striatura milium
Vitrina limpida
Strobilops labyrinthica
Succinea ovalis

Stations 8.—Rolling, morainic hills east of Camp Idlewild. Rather high hills rising from low, swampy areas. Summit of hills with pine, birch, aspen and basswood, all second growth. An occasional pine of the original forest. Logged and burned over. Woods rather open and ground with little vegetation, usually. Low areas with willow, birch and aspen, bordering bogs with sedge, cattails, horsetails, etc. Mollusks absent from higher hills and apparently rare in low places under debris.

Discus cronkhitei anthonyi
Zonitoides arboreus
Cochlicopa lubrica
Strobilops labyrinthica

Collecting Stations for Aquatic Mollusca

Station 11 (Fig. 3).— West shore North Star Lake near Northwood Resort. Water one foot deep, mud bottom, vegetation *Chara* and *Potamogeton.*

Fig. 3. Station 11. Boggy shore on west side of lake.

Amnicola limosa porata
Amnicola lustrica decepta
Valvata tricarinata
Acella haldemani
Gyraulus parvus
Ferrissia parallela
Physa gyrina
Bulimnea megasoma

Stations 12, 14, 18.—West shore north bay, opposite Camp Idlewild. Water 2-3 feet deep (1 m.), sandy silt and mud bottom. Vegetation of *Chara, Pomatogeton,* (several species), *Vallisneria, Scirpus, Lemna, Nymphaea, Castalia, Myriophyllum. Amnicola, Valvata* obtained by sweeping *Chara* with Walker dredge. *Sphaerium* and *Pisidium* in mud bottom. *Physa* and *Helisoma* in vegetation.

Sphaerium sulcatum
Pisidium species
Pisidium species
Valvata tricarinata
Amnicola limosa porata
Amnicola lustrica decepta
Lymnaea stagnalis jugularis
Helisoma anceps striatum
Helisoma campanulatum
Helisoma trivolvis macrostomum
Gyraulus parvus
Physa gyrina

Station 15.—North Bay of North Star Lake opposite Camp Idlewild. Water 8 meters deep. Silt bottom.
Pisidium, two species.

Stations 16 and 17.—North shore north bay, North Star Lake. Water 2-3 feet deep. Vegetation same as at stations 12, 14, 18. Snails mostly on under side of water lily leaves. *Amnicola* in *Chara.*

On bottom: *Sphaerium sulcatum*
In *Chara: Valvata tricarinata*
Amnicola limosa porata
Amnicola lustrica decepta
Pisidium, two species.
Helisoma anceps striatum
Helisoma campanulatum
Physa gyrina

On pond lily leaves:

Lymnaea stagnalis jugularis
Helisoma trivolvis macrostomum
Helisoma campanulatum
Helisoma anceps striatum
Physa gyrina
Ferrissia fusca

Station 13.—Ditch beside road near Camp Idlewild. Water 2-8 inches deep. Bottom of leaf debris in soft mud. Mollusks in debris.

Gyraulus circumstriatus *Pisidium* species.

Fig. 4. Station 19. Shallow shore with sand and silt bottom and with abundant vegetation. Note that forest descends to shore of lake.

Station 19 (Fig. 4).—Bay northeast side of lake south of Camp Idlewild. Water 2-3 feet deep (1 m.), rocky bottom near point, sand and sandy silt east of point. Bottom shelves off very gradually into deep water, depth increasing very slowly. Sandy and rocky areas with *Scirpus*, bottom with much debris, including dead shells of mussels and gastropods. Living mussels abundant on sandy bottom where there is some *Chara*. The following species were collected from the bottom.

Lampsilis siliquoidea rosacea
Anodonta kennicotti
Anodontoides modesta
Sphaerium sulcatum
Pisidium (four species)
Helisoma campanulatum
Fossaria obrussa decampi
Amnicola limosa porata

Eastward from the point the bottom changes to sandy silt, almost mud, and the vegetation assumes the character of that recorded in stations 12, 14, and 18 (Fig. 5). Gastropods were abundant at thiss tation, mostly on the vegetation.

Fig. 5. South of station 19. Bog bottom. A pond lily community of Nymphaea and Castalia.

Valvata tricarinata	*Gyraulus parvus*
Amnicola limosa porata	*Menetus exacuous*
Helisoma campanulatum	*Fossaria obrussa decampi*
Helisoma anceps striatum	*Physa gyrina*
Gyraulus deflectus obliquus	*Succinea retusa* (on pond lily leaves)

Station 20 (Fig. 6).—Shallow bar between upper lake and west bay of lake. Water from one to three feet in depth (1 m.), bottom soft muck

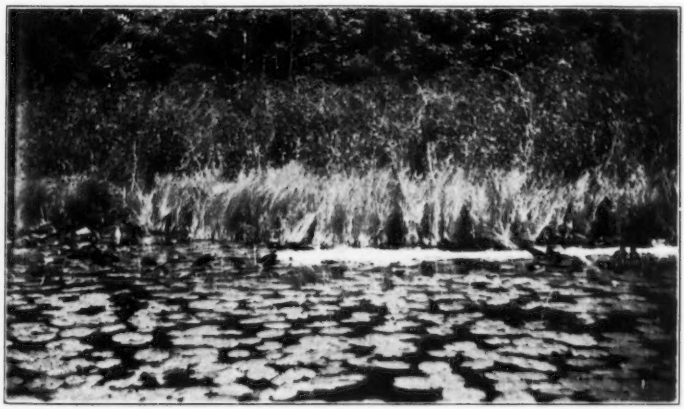

Fig. 6. Station 20. Shore at entrance to west bay. Bog bottom, sedge-lined shore and pond lily community. Typical habitat for Bulimnea.

composed of lake detritus from animal and plant debris. Vegetation very thick, consisting of *Scirpus* (round), several species of *Potamogeton (P. natans, P. perfoliatus* and others), water lilies *(Nymphaea* and *Castalia), Valisneria, Lemna, Myriophyllum, Chara, Nitella; Typha* bordering shore. Animal life abundant. Mollusks from following vegetation.
From Chara and Nitella:

Amnicola limosa porata
Valvata rticarinata
Helisoma campanulatum (rare)

From pond liliy leaves:

Helisoma campanulatum
Helisoma anceps striatum
Cyraulus parvus
Amnicola limosa porata
Physa gyrina

From Potamogeton and general mass vegetation:

Lymnaea stagnalis jugularis
Helisoma campanulatum
Helisoma anceps striatum
Physa gyrina

From muddy shore, water one foot deep, snails on bottom or floating on top of water. Bank of shore here is a floating bog.

Lymnaea stagnalis jugularis
Helisoma trivolvis macrostomum

Bulimnea megasoma (laying eggs at this time, middle of August).

Station 21.—Little North Star Lake, bordering shore. Water shallow (one to three feet), bottom mud or silt, in most places mucky; vegetation of *Typha, Scirpus, Potamogeton, Nymphaea, Castalia, Lemna, Chara.*

Anodonta grandis footiana
Anodonta marginata
Sphaerium sulcatum
Musculium securis
Musculium truncatum
Pisidium (four species)
Valvata tricarinata simplex
Amnicola limosa porata
Amnicola lustrica decepta
Lymnaea stagnalis jugularis
Bulimnea megasoma
Stagnicola exilis
Acella haldemani
Helisoma anceps striatum
Helisoma trivolvis macrostomum
Helisoma campanulatum
Planorbula armigera
Menetus exacuous
Cyraulus parvus
Cyraulus cristus

Station 22.—Shallow near south end of Little North Star Lake. Water three feet deep (1 m.). Vegetation as in station 21. Muck bottom. Life on vegetation, obtained by sweeping with Walker dredge.

Musculium securis
Pisidium, two species
Valvata tricarinata simplex
Valvata tricarinata unicarinata
Amnicola limosa porata
Amnicola lustrica decepta
Fossaria obrussa decampi
Helisoma anceps striatum
Helisoma trivolvis macrostomum
Helisoma campanulatum
Menetus exacuous
Gyraulus deflectus obliquus
Cyraulus parvus
Physa gyrina
Succinea retusa

Station 23.—Marl bed under peat-like stratum, Little North Star Lake. Water three feet deep (1 m.). Marl bed of unknown depth.

Musculium securis
Musculium truncatum
Valvata tricarinata simplex
Amniola limosa porata
Amnicola walkeri
Fossaria obrussa decampi
Helisoma campanulatum
Menetus exacuous megas
Gyraulus deflectus obliquus
Gyraulus altissimus
Gyraulus cristus
Ferrissia parallela

Station 24 and 25.—North bay North Star Lake, shore at Camp Idlewild. Sand bottom, water 2-4 feet deep (1-1½ m.). Vegetation of *Chara* and *Scirpus*.

Lampsilis siliquoidea rosacea
Anodonta marginata
Anodonta kennicotti
Anodontoides modesta
Amnicola limosa porata (Chara)
Valvata tricarinata (Chara)
Ferrissia parallela (in mussel shell)

Station 26.—Summer-dry pool beween North Star Lake and Little North Star Lake. Dry in August and filled with sedge. Bottom of leaf debris baked hard by sun.

Sphaerium occidentale
Gyraulus circumstriatus

Station 27.—Swale in woods one mile east of Camp Idlewild. Dry in August and covered with dried pond scum *(Spirogyra)*. Shells under *Spirogyra*.

Pisidium (two species)
Aplexa hypnorum
Gyraulus umbilicatellus

Station 28.—Stagnant pool on roadside one-half mile east of Camp Idlewild. Shallow with muck bottom. Water covered with *Spirogyra*. Mollusks abundant and but one species represented.

Helisoma trivolvis.

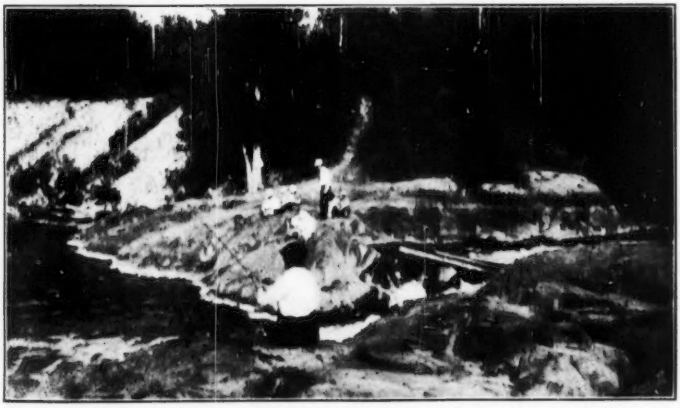

Fig. 7. Big Falls, Big Fork River. Falls flow over rock sill. A famous fishing locality.

Station 29 (Fig. 7).—Big Falls of Big Fork River, Koochiching County. Above falls in mud bottom near shore. No vegetation. Land snails under logs near shore. Aquatic species as follows, *Ferrissia* in empty valve of *Lampsilis*.

Lampsilis siliquoidea
Lampsilis ventricosa occidens
Sphaerium stamineum
Campeloma rufum
Amnicola limosa porata
Ferrissia rivularis
Ferrissia trada

Land snails:

Zonitoides arboreus
Helicodiscus parallelus

Station 30.—Southwest side main body of North Star Lake, 75 m. from shore. Water 30 meters deep, bottom soft mud. Only life few *chironomid* larvae and empty shells of *Pisidium*.

Systematic Discussion of Species Collected

Pelecypoda

Unionidae

The naiades are abundant in North Star Lake and vicinity. They were abundant at stations 19, 24, and 25, usually on a sandy battom in water from two to four feet deep. The vegetation of the habitats consisted chiefly of *Chara* and *Scirpus*. On the points the bottom is slightly rocky. The North Star Lake naiades collected consist of:

Anodonta kennicotti Lea.

Anodonta marginata Say. Also in Little North Star Lake.

Anodontoidae modesta (Lea).

Lampsilis siliquoidea rosacea (De Kay).

Anodonta grandis footiana Lea. This species was found only in Little North Star Lake on a mud bottom in shallow water.

Lampsilis siliquoidea (Barnes).

Lampsilis ventricosa occidens (Lea). These two species were collected in Big Fork River, above Big Falls, Koochiching Co. They live near shore in comparatively shallow water.

Sphaeriidae

The little fingernail shells were not very abundant in Nort Star Lake and only a few species were collected.

Sphaerium sulcatum (Lam.). Stations 12, 14, 18, 19, 21. Usually in sandy silt or mud bottom in water 2-3 feet deep (1 m.).

Sphaerium stamineum (Conrad). Big Fork River above Big Falls, Koochiching Co. Along shore in clay bottom in shallow water.

Sphaerium occidentale (Prime). Summer dry pool between North Star Lake and Little North Star Lake. Very abundant under leaves and bottom debris.

Musculium truncatum (Linsley).

Musculium securis (Prime). Stations 21, 22, 23, in Little North Star Lake in shallow water, muck bottom. Apparently not common.

Pisidium, several species.

Pisidia occurred at stations 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, and 27. Possibly six or seven species are represented. Since the death of Dr. V. Sterki, who made this group a life study, there has been no authority to consult regarding their identification and the writer does not feel competent to undertake the task. The greater number were found in shallow water on silt or mud bottom but at station 15 two species of *Pisidium* were dredged from a depth of 9 meters, silt bottom. Empty shalls were also dredged from a depth of 30 meters, soft mud bottom in the deep hole at the lower end of the lake. They were associated with chironomid larvae.

Gastropoda

Valvatidae

Valvata tricarinata (Say). Stations 11, 14, 18, 19.

Valvata tricarinata unicarinata Haldeman. Station 22.

Valvata tricarinata simplex Gould. Stations 21, 22, 23. Typical *tricarinata* occurred more or less abundantly on mud and silt bottom in shallow water, usually in *Chara*, where it was obtained by sweeping with a Walker dredge. The varieties *unicarinata* and *simplex* occurred only in Little North Star Lake, a small body of water, usually on a mud bottom in such vegetation as *Pomatogeton* and *Nymphaea*. The *simplex* form was the most abundant.

Viviparidae

Campeloma milesii (Lea). Big Fork River, above Big Falls, Koochiching Co., near shore in shallow water, soft clay bottom. This species of *Campeloma* appears to replace the eastern *decisum* in the middle west. The species is known from Wisconsin, and Michigan. See Moll. Wis., I, p. 61 for figures and descriptions of the species as it occurs in Wisconsin. It appears to be largely a river form in Minnesota and Wisconsin.

Amnicolidae

The little Amnicolas are very abundant in North Star Lake, their favorite habitat being in masses of *Chara* on a sandy bottom in water two to four feet deep. Quantities could be obtained by sweeping over the Chara beds with the Walker dredge. Occasionally, they are found on other vegetation, as leaves of *Castalia*, *Nymphaea*, and *Potamogeton*.

Amnicola limosa porata Say. This is the most abundant *Amnicola* in the lake. It is typical of the variety *porata* as found in the type locality, Cayuga Lake, N. Y. There is the usual sexual variation, the males having longer and more scaliform spires than the females. It was found at stations 11, 12, 14, 16, 17, 18, 19, 21, 22, and 23. Several of these are in Little North Star Lake.

Amnicola limosa parva Lea. Big Fork River above Big Falls, Koochiching Co. Near shore on a clay bottom in shallow water. This small form of *Amnicola* appears not to differ from the race *parva*.

Amnicola walkeri Pilsbry. This little *Amnicola* was more abundant in Little North Star Lake than in North Star Lake. It occurs in shallow water on vegetation growing on a muck bottom. It is typical of the species. Found at three stations, 19, 21, and 23.

Amnicola lustrica decepta F. C. Baker. This *Amnicola* is almost as abun-

dant as *A. limosa porata* and is found under the same conditions, mostly in *Chara* beds. The form in North Star Lake is somewhat narrower on the whole than the typical form of *decepta*, recalling somewhat the turreted species of Oneida Lake, N. Y., called *oneida* Pilsbry. *Decepta* is characteristic of lakes and is easily separated from the typical form of rivers, typical *lustrica* Pilsbry, with its slight umbilicus and flatter whorls. *Decepta* was found at the following stations: 11, 14, 16, 18, 19, 21, 22. Several of these are in Little North Star Lake.

Lymnaeidae

Lymnaea stagnalis jugularis Say. Abundant at stations 12, 14, 16, 17, 18, 20, 21, usually among vegetation which grows on a mud bottom in water 2-4 feet deep. Frequently seen crawling on the under surface of the water film. The shells are large, 50 mm. in length and all are typical of the variety, though showing some variation in the form of the aperture.

It is to be regretted that it seemed necessary to change Say's familiar name *appressa* to that of *jugularis* of the same author. Say's statement that "there is a species of this genus which resembles the *stagnalis* of Europe" seems to fix the form as of the typical *Lymnaea* type and this can only be construed as being the same as his *appressa*. The length, about one inch, indicates a young shell, which fits Say's description, even to the 'very distinct' umbilicus which is apparent in some young specimens. The statement that a specimen was brought from the West Indies, by Mr. L'Herminier, of Charleston, is of course erroneous for no member of the stagnalis group is found in the West Indies. This appears to be a plain case of priority and there is no reason whiy the name should be used in place of *appressa*.

Bulimnea megasoma (Say). This finest of American Lymnaeas was not uncommon in both North Star Lake and Little North Star Lake. It was found at stations 11 and 20 (see Figs. 3, 6) in North Star Lake. The habitat was invariably in quiet water near shore where the bottom is composed of soft, sticky mud and detritus. Often the water was but one to two feet deep but the mud was from two to four or five feet deep. All habitats personally visited in Wisconsin and Minnesota were of the bog character. The species does not always occupy this kind of an environment as noted by Rush in Georgian Bay where it occupies a deep water habitat subject to wave action (see Moll. Wisconsin, I, p. 281). The animals were depositing eggs the second week of August.

Stagnicola exilis (Lea). Little North Star Lake, near shore in shallow water among plants in shallow water. Typical specimens obtained.

Acella haldemani ('Deshayes' Binney). Station 11 in North Star Lake and in Little North Star Lake. Apparently rare as only one specimen was found at each station, dredged in bottom material.

Fossaria obrussa decampi (Streng). Found living at station 19, North Star Lake and fossil at stations 22 and 23, in marl, Little North Star Lake. Living on sandy silt bottom in water two feet deep. This species is very abundant as a Pleistocene fossil but is rarer in the recent fauna. Possibly another species approaching extinction.

Planorbidae

Helisoma anceps striatum (F. C. Baker). Stations 14, 17, 18, 19, North Star Lake; 21, 22, Little North Star Lake. Usually found in shallow water among vegetation growing on a mud or clay bottom. The shells of this race living in this vicinity are all referable to the race *striatum*, which is not, as once believed, an extinct race. The race is more abundant in the north and its presence as a fossil farther south probably indicates colder water then than now. It is greatly to be regretted that the supposedly fixed name of *antrosum* Conrad should have to be displaced by *anceps* Menke but the case is one of simple priority, Menke's name having been overlooked by all workers. Dr. Pilsbry is the first conchologist to apply Menke's name.

Helisoma trivolvis (Say). Station 28, a stagnant pool near road to Camp Idlewild, water shallow near shore and bottom soft, mucky. *Spirogyra* only vegetation. These shells differ from the *trivolvis* of New York State in having the whorls of the umbilical side wholly without transverse striae or ridges. They are all well rounded, slowly increase in size and are marked only by lines of growth. More than three whorls are visible on the umbilical side while in typical *trivolvis* only two and a half or rarely three full whorls are visible. In form they resemble *pseudotrivolvis* F. C. Baker, but in this race the inner whorls of the umbilical region are strongly ridged. This might pass for an ecological variety or form but had better remain unnamed for the present. It was abundant in this pool.

Helisoma trivolvis macrostomum (Whiteaves). This large race of *trivolvis* is common in many places in North Star and Little North Star Lake. It was collected at stations 18, 20, 21, 22. It lives in the same habitat with *Lymnaea stagnalis jugularis* and *Bulimnea megasoma*. Many specimens attain a diameter of 25 mm. This race replaces typical *trivolvis* in many northern lakes, especially in Canada.

Helisoma campanulatum (Say). Abundant at stations 12, 14, 17, 18, 19, 20, in North Star Lake; stations 21, 22, 23 in Little North Star Lake. The material includes all sizes although the great majority of specimens are large and typical.

Planorbula armigera (Say). Abundant at station 22, Little North Star Lake, on vegetation in shallow water. Less abundant at stations 17 and 21. It was found only at one station in North Star Lake, 17. This species prefers the quiet waters of a small lake or pond where there is abundant vegetation and a mud bottom.

Menetus exacuous (Say). Stations 19 and 21. Usually near shore in shallow water on vegetation. More abundant at station 21 in Little North Star Lake.

Menetus exacuous megas Dall. Stations 22, 23 in Little North Star Lake. Habitat same as for the typical form. Station 23 is a marl bed.

Gyraulus deflectus obliquus (DeKay). Stations 19, 22, 23, the latter a marl bed. Same habitat as for *Menetus*. The race is typical but specimens were not common.

Gyraulus parvus (Say). Stations 11, 14, 19, North Star Lake; stations 21, 22, Little North Star Lake. Usually on vegetation, often pond lily leaves. The *parvus* of these lakes do not differ from the species as found in New York state.

Gyraulus circumstriatus (Tryon). Station 13, a small ditch near Camp Idlewild, and station 26, a small summer-dry pool between the two lakes. In the ditch the water was a few inches deep and was filled with leaves and debris of various kinds. This is the most northern record for this species. In Wisconsin, it occurs at the west end of Lake Superior at Bayfield. The specimens are typical though small.

Gyraulus altissimus (F. C. Baker). Station 23, a marl bed in Little North Star Lake. Typical and abundant. None were found in the recent fauna.

Gyraulus umbilicatellus (Ckll.). Station 27, a swale in the woods one mile ease of Camp Idlewild. Dry in August. The specimens are typical though small.

Gyraulus cristus (Linn.). Stations 21 and 23, the latter a marl bed. At station 21 living in shallow water among vegetation.

Ancylidae

Ferrissia parallela (Say). Station 11, North Star Lake, on lily leaves. Station 23, Little North Star Lake in marl bed. Station 25, in dead mussel shell. The latter habitat is rare for *parallela* as it is usually found on vegetation.

Ferrissia rivularis (Say). Station 29, Big Fork River above Big Falls, Koochiching Co. In empty naiad valve near shore.

Ferrissia tarda (Say). Station 29, same location as *Ferrissia rivularis*.

Ferrissia fusca (C. B. Adams). Station 17, North Star Lake, on pond lily leaves.

Physidae

Physa gyrina Say. Stations 11, 14, 16, 17, 18, 19 in North Star Lake; station 22 in Little North Star Lake. *Physa* is usually found on vegetation, mostly on the upper side of pond lily leaves. In August young individuals predominated, adults being very scarce. All specimens have very thin shells.

Aplexa hypnorum (Linn.). Station 27, swale in woods one mile east of Camp Idlewild. Dry in August. Asociated with *Gyraulus umbilicatellus*.

Zonitidae

Euconulus fulvus (Müller). Stations 1, 2, 4, 5, 10, most abundant at station 4. The usual habitat was under the debris of the forest floor, although several specimens were found under started bark on fallen logs.

Vitrina limpida (Gould). Stations 3 and 10. Collected from debris of forest floor. Not common.

Retinella binneyana (Morse). Stations 1, 2, 3, 4, 5, 7, 10. This hyaline snail was found under several different conditions. It was most common on the forest floor under debris. Also under logs with started bark, at the base of stumps, and under brush. All of the Retinellae appear to be referable to the northern species *binneyana*.

Hawaiia minuscula (Binney). Station 3, in debris of forest floor. Not common.

Striatura milium (Morse). Stations 3 and 10. Collected from forest floor in debris.

Zonitoides arboreus (Say). Stations 1, 2, 3, 4, 5, 6, 8, 10, Itasca Co. Station 29, Koochiching Co. Found commonly in all situations, the most abundant and widely distributed snail in Minnesota.

Endodontidae

Anguispira alternata (Say). Station 4, in low marshy woodland. Apparently rare as only two specimens were found. This is the only large snail found in the vicinity studied.

Discus cronkhitei anthonyi (Pilsbry). Stations 1, 2, 3, 4, 5, 8, 10, base of rotting stumps and floor of forest in debris. All of the *Discus* from the region of North Star Lake are referable to *anthonyi* none to *catskillensis* (Pilsbry) as might be expected from this northern region.

Helicodiscus parallelus (Say). Stations 2, 4, 5, 10, Itasca Co.; Station 29, Koochiching Co. Common under the debris of the forest floor, under started bark, and at the base of rotting stumps.

Planogyra asteriscus (Morse). Station 7, in leaf mold on the forest floor. Rare.

Pupillidae

Gastrocopta tappaniana (C. B. Adams). Stations 3, 4. Under started bark and in leaf mold on the forest floor. Not common.

Vertigo ventricosa (Morse). Stations 3, 4, associated with *Gastrocopta tappaniana.*

Strobilopsidae

Strobilops labyrinthica (Say). Stations 1, 2, 3, 4, 5, 6, 8, 10. Everywhere fairly common, under bark, in the debris of the forest floor, and at the base of stumps. All of the material collected belongs to the typical form.

Vallonidae

Vallonia gracilicosta Reinhart. Stations 2 and 5. In the debris of the forest floor and in rotting stumps of birch. *Gracilicosta* is common in Minnesota. It has been seen from Birch Point, Vermilion Lake, St. Louis Co., Minneapolis, Hennepin Co., and Thief River Falls, Pennington Co.

Cochlicopidae

Cochlicopa lubrica (Müller). Stations 1, 3, 4, 5, 8. Not abundant. Usually found in debris of the forest floor.

Succineidae

Succinea ovalis Say. Stations 3 and 10. Apparently rare as only two immature specimens were found. Both specimens were found in the upland forest floor under debris.

Succinea retusa Lea. Stations 6, 9, 19, 22. Small specimens were found bordering the shore of North Star Lake and Little North Star Lake.

Auriculidae

Carychium exile canadense Clapp. Stations 3, 4, 5, under rotting stumps of birch and in the debris of the forest floor. Common.

Faunal papers on Minnesota Mollusca

This list includes only those papers which list Mollusca specifically from the state of Minnesota. There are several papers which describe new species from this state or list the region in connection with monographic studies.

BAKER, FRANK COLLINS. 1929—Mollusca from Vermilion and Pelican lakes, Minnesota, with the description of a new variety of Helisoma corpulenta. Nautilus **42**:95-97, 131-136.

COOPER, WILLIAM. 1834—List of shells collected by Mr. Schoolcraft in western and northwestern territory.. Appendix to narrative of expedition through upper Missouri to Itaska Lake, etc., under direction of Henry B. Schoolcraft. p. 153-156.

DANIELS, L. E. 1909—Records of Minnesota mollusks. Nautilus **22**:119-121.

GRANT, ULYSSES S. 1886—Conchological notes. An. Rep., Geol. and Nat. Hist. Surv. Minn. **14**:114.

———1888—Notes on the molluscan fauna of Minnesota. An. Rep., Geol. and Nat. Hist. Surv. Minn. **16**:481.

GRIER, NORMAN M. 1922—Final report on the study and appraisal of mussel resources in selected areas of the upper Mississippi river. Amer. Midl. Nat., **8**:1-33, 1 map.

———1926—Report on the study and appraisal of mussel resources in selected areas of the upper Mississippi rvier, 1920-25. Amer. Midl. Nat. **10**:89-110.

GRIER, N. M. AND J. F. MUELLER. 1922—Notes on the naiad fauna of the upper Mississippi river. II. The naiads of the upper Mississippi drainage. Nautilus **35**:46-49, 96-103.

HOLZINGER, JOHN M. 1888—Notes on the Mollusca of Winona County. An. Rep. Geol. and Nat. Hist. Surv. Minn., **16**:485.

SARGENT, H. E. 1895-1896—Annotated list of the Mollusca found in the vicinity of Clearwater, Wright Co., Minnesota. Nautilus **9**:87-90, 125-128.

STEARNS, R. E. C. 1900—List of shells collected by Vernon Baily in Huron and Eagle lakes, Minnesota, with notes. Proc. U. S. Nat. Mus. **22**:135-138.

WILSON, CHARLES B. AND ERNEST DANGLADE. 1914—The mussel fauna of central and northern Minnesota. Rep. U. S. Comm. Fish. **1913**. Appendix V, pp. 1-26.

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RECORDS OF AMPHIBIANS IN THE SOUTHEASTERN STATES

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During late years herpetological activity in this region has greatly increased, and knowledge of the subject has advanced correspondingly. Nevertheless a vast amount of field work remains to be done for the multiple purpose of filling distributional gaps, gaining better insight into taxonomic problems, and adding bit by bit to the incompletely recorded life histories. The following notes have been assembled as a slight contribution toward these ends. They result primarily from eleven trips to the Southeastern States, beginning in 1912, with Okefinokee Swamp as the principal focus of operations. A few additional notes are included on the basis of certain specimens examined in the collection of the Academy of Natural Sciences of Philadelphia. A fair proportion of the distributional data represent new county records.

Various traveling companions have shown great patience with a frog-catcher's vagaries, besides rendering appreciated assistance, on the more recent trips: my wife, Jean Sherwood Harper, in 1930, 1931, and 1932; Gertrude H. Robinson in 1932; the late William B. Harper in 1931 and 1933; and Arthur N. Leeds in 1933 and 1934. I am also indebted to a number of other friends (whose names appear in subsequent pages) for information, specimens, or aid in identification.

Most of my own specimens have been, or will be, deposited in the Academy of Natural Sciences of Philadelphia or the United States National Museum.

Amphiuma means Garden. CONGO EEL

Georgia.—A local name for *Amphiuma* in Okefinokee Swamp is "Snake Eel." It is reported from the St. Mary's River near St. George as "Lamper Eel," and from Camden County as "Lampus Eel." All the following records are from Okefinokee Swamp.

In 1916 Farley Lee spoke of a large "Snake Eel" that used to have a lair in the water beneath a tussock at his camp on the Big Water. When he would wash a piece of meat in the water, the *Amphiuma* would dart out, seize the meat, and attempt to carry it off beneath the tussock. "An' if yer didn't have a good holt on it, he'd git it."

I had hesitated to use this report, until I came across Shufeldt's account (1883, p. 160) of similar rapacity on the part of a captive *Amphiuma tridactylum* from Louisiana. Furthermore, the following reports of attacks upon *Amphiuma* resulting fatally to various snakes gain in credibility by the fact that they come from independent sources at intervals of years.

Farley Lee reported having seen one morning, about 1910, a "Moccasin" (either *Natrix* or *Agkistrodon)* fighting a "Snake Eel" on the Gator Branch, a tributary of the Suwannee River near its emergence from Okefinokee Swamp.

In the afternoon both creatures were found dead, the "Snake Eel" being part way down the snake's throat.

In 1922 L. B. Ricketson reported seeing a snake on the bank of the Suwannee Canal, holding an *Amphiuma* by the middle. The latter was struggling in the edge of the water, and making a sound suggestive of a house cat's squalling.

In 1929 W. R. Spaulding reported two cases of a snake succumbing in an attempt to swallow an *Amphiuma*. One was a "Moccasin" (presumably *Natrix),* and the other a King Snake *(Lampropeltis g. getulus).* He had made these observations in cypress bays.

On July 28, 1922, I noticed a two-foot *Amphiuma* wriggling in serpentine curves across a muck surface beside a prairie "head" at Monkey Lake in Grand Prairie. In a few moments it nosed into the muck and slid from view.

On June 16, 1929, I secured a 590-mm. specimen in a Schuyler trap, baited with bacon and cheese and set on a feeding-stand of the Everglade Water-rat *(Neofiber alleni nigrescens)* on Floyd's Island Prairie. The animal was caught by the head, and the rest of its body extended into one of the two tunnels leading to the feeding-stand. It was interesting to find it making such use of the Water-rat's engineering works.

On July 23, 1931, I noticed an *Amphiuma* lying on its back in a cypress bay adjoining Chesser's Island. It was evidently about to succumb to some serious old wounds about the head and along the side. It measured about 844 mm. in length.

Ambystoma opacum (Gravenhorst). MARBLED SALAMANDER

North Carolina.—On April 4, 1932, one was found under a log in a dry cypress swamp at Lake Waccamaw, Columbus County.

Plethodon glutinosus (Green). SLIMY SALAMANDER

South Carolina.—On April 6, 1933, one was found beneath a plank on the bank of the Santee Canal, in a swamp near Monks Corner, Berkeley County.

Desmognathus fuscus auriculatus (Holbrook). SOUTHERN DUSKY SALAMANDER

Georgia.—Several were collected under logs in the swamp along Suwannee Creek, Ware County, on April 20 and 22, 1932 (Fig. 1). The creek was then dried up, except for some stagnant water remaining in a few expansions of its bed.

Four topotypes from the vicinity of Riceborough, Liberty County, were secured from Ernest Bacon on April 8, 1933. The largest is 119 mm. in length.

Florida.—On August 16, 1921, six specimens were taken beneath boards and logs beside a large spring pool near the St. Mary's River north of Boulogne, Nassau County. Another salamander, presumably of the same species, wriggled across the pool and started to climb out on some vertical boards. At that moment a small "Red-finned Pike" *(Esox americanus)*

snapped at it. When presently the "Pike" was captured, only the tail of the salamander was found in its throat.

Desmognathus quadramaculatus (Holbrook)

The original publication of this species was in the excessively rare Vol. 4 (1840) of the first edition of Holbrook's "North American Herpetology." The name appears as *Salamandra quadramaculata* (without hyphen) on plate "27" [=26], opposite page 121, but as *Salamandra maculo-quadrata* in the table of contents at the beginning of the book and in the text on pages 121 and 122. In most of the current literature the name *quadramaculatus* is improperly hyphenated.

North Carolina.—On May 3, 1933, four specimens (the longest 106 mm.) were taken in a rocky brook (apparently a tributary of the Horsepasture River) between Lake Toxaway and Sapphire, in Transylvania County (alt. about 3200 ft.). On May 4 two others (56 and 114 mm.) were taken in a rocky tributary of Buck Creek (alt. about 1900 ft.), about 2 miles south-

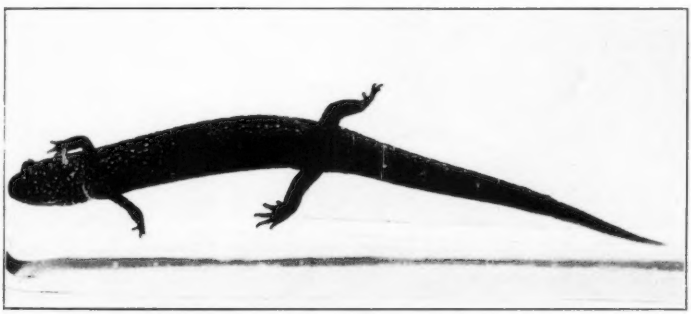

Fig. 1. *Desmognathus fuscus auriculatus*, 91 mm. (F. H. No. 133.) Suwannee Creek, Ware County, Ga. April 21, 1932.

east of Buck Creek Gap, in McDowell County. These specimens have been determined by Dr. S. C. Bishop and Dr. E. R. Dunn.

Siren intermedia Le Conte. Le Conte's Mud-eel

Georgia.—*Siren* is a common animal in the lakes and cypress ponds of Okefinokee Swamp. The name of "Lamper Eel" seems to be applied to it by some, who may not clearly distinguish it from *Amphiuma*.

On May 25, 1930, I secured a 133-mm. specimen (with 32 costal grooves) in a cypress pond on Chesser's Island. On July 20, 1931, I secured two others in a small pond in a sphagnous bog on the eastern border of this island. Probaby both were skulking beneath floating clumps of *Eriocaulon*, which I scooped up with a dipnet. Sphagnum was growing thickly in both ponds.

The larger of these last two specimens (Fig. 2) is 212 mm. in length;

tail, 85; arm, 12.5; number of costal grooves, 31. In life, its color was noted as olive-green, with minute black spots. In spirits, the venter is dark plumbeous slate. The tail is keeled, except for about 25 mm. at the ventral base.

The smaller specimen is 135 mm. in length; tail, 50; arm, 6; number of costal grooves, 32. In life, it was apparently blackish all over; in spirits, still darker spots are faintly evident, chiefly on the tail.

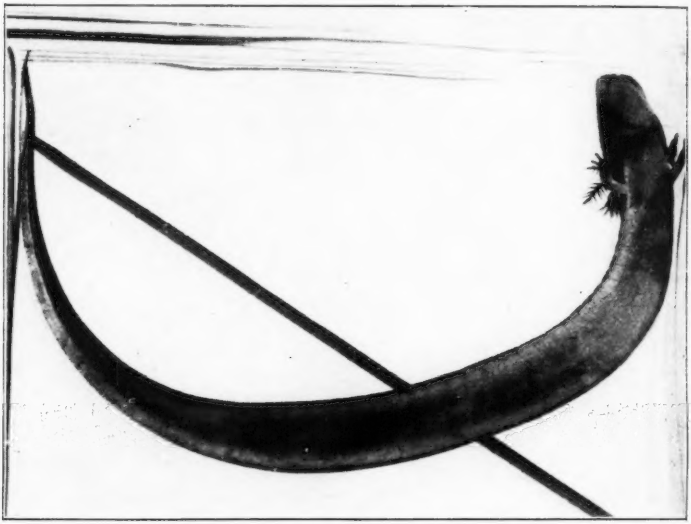

Fig. 2. *Siren intermedia*, 212 mm. (U. S. N. M. No. 84638.) Chesser's Island, Okefinokee Swamp, Ga. July 20, 1931.

The number of costal grooves places all these specimens in the species *intermedia*, as defined by Noble and Marshall (1932).

The scant original description of this species was published in a paper by Harlan (1827, p. 322), but was accredited to John Eatton "Le Conte, manuscript notes"; no more definite statement of its range was furnished than the remark, "Inhabits the southern states." In Le Conte's own description, published the following year (1828, p. 133), it was merely said to be "an inhabitant of the same country as the two other species already known." These two species were *Siren lacertina* Linnaeus, 1766 ("Habitat in Carolinae paludosis"), and *Siren striata* Le Conte (1824, p. 53), whose range was not stated in the original description. According, however, to Harlan (1827, p. 322), the latter "inhabits South Carolina." Up to this point, representations might be made more or less logically in behalf of South Carolina as the restricted type locality of *S. intermedia*. But Holbrook in 1842 (ed. 2, vol. 5, p. 108) throws new and fairly conclusive light on the situation: "This reptile

inhabits Georgia and South Carolina; Leconte observed it in the former, and Dr. Blanding in the latter state." The natural location for Le Conte's observations would have been the family plantation in Liberty County. At any rate, Cope (1889, p. 229) records six specimens of "*Siren lacertina*" collected by Dr. W. L. Jones—two (U. S. N. M. No. 5040) from "Georgia," February 1, 1861, and four (U. S. N. M. No. 4535) from "Riceborough, Ga.," date not specified. At least the majority of these specimens are identified by Noble and Marshall (1932, p. 3) as *Siren intermedia*. Thus there would appear to be no impropriety in hereby restricting the type locality to the vicinity of Riceborough, Liberty County, Ga.

Pseudobranchus striatus (Le Conte). STRIPED MUD-EEL

Georgia.—On May 25, 1930, I secured three specimens (93, 104, 105 mm.) in a partly dried-up and sphagnum-filled cypress pond on Chesser's Island. They were apparently in the bottom muck. On July 20, 1931, I found another (Fig. 3) in the same habitat with the two specimens of *Siren* collected on that date. Its length is 159 mm.; tail, 74; arm, 4. Coloration in spirits: head and dorsum fuscous; venter slaty gray, finely speckled with creamy white; upper lateral stripe buffy, lower creamy white; space between lateral stripes intermediate in color between dorsum and venter, speckled like venter. Tail with keel, the dorsal portion extending for about 48 mm., the ventral portion for about 37 mm., from the tip; eyes scarcely developed; mouth subterminal, scarcely more than large enough for the insertion of a common pin. Obviously the size of food objects that can be swallowed by such an animal is severely limited.

On April 10, 1932, in digging a fire trench in a damp spot in the swamp near Chesser's Island, Ben Chesser unearthed two individuals. It was a time of severe drought, and there was no water at the spot. The gills of one specimen (110 mm.) are so reduced in size as to be difficult to distinguish except with a hand lens, and seem to be covered anteriorly with a membrane. Possibly this was an adaptation to the prevailing drought conditions (cf. Viosca, 1925). On April 13, 1932, a dried-up specimen was found on the muddy surface of Chesser's Prairie, where fire had recently swept.

In describing *Siren striata* in 1824 (p. 53), Le Conte followed his common practice at that period in failing to state the type locality or the range of the new species. However, in the account of the preceding species (*Siren intermedia*), it has been indicated that Le Conte was acquainted with both that animal and this one in Georgia. Harlan, in accordance with his habit of making free use of the notes and materials of others, gave (1827, p. 322) a brief redescription, obviously copied from Le Conte, but added that it "inhabits South Carolina."[1] In 1838 (ed. 1, vol. 2, p. 5) Holbrook made the

[1] By also including the remark, "Vulgo, *guana*," Harlan showed that in some way he had acquired knowledge of a local name. It is probably with reference to this same name that Le Conte says (1828, p. 134): "I have little doubt from the fact of Africans giving a name to the Siren striata, that some animal resembling it may be found in the swampy regions of their country." It would be very interesting to ascertain whether such a name as "Guana" is still employed by the colored population of Liberty County.

following acknowledgment to Dr. J. M. B. Harden, a nephew-in-law of Major Le Conte's: "I have to thank Dr. Harden, of Riceborough, Georgia, for several living specimens of Batrachian animals, as the Siren striata, &c." He also wrote of the species in 1842 (ed. 2, vol. 5, p. 110): "It is again to that accurate naturalist Leconte that we are indebted for a knowledge of this beautiful reptile."

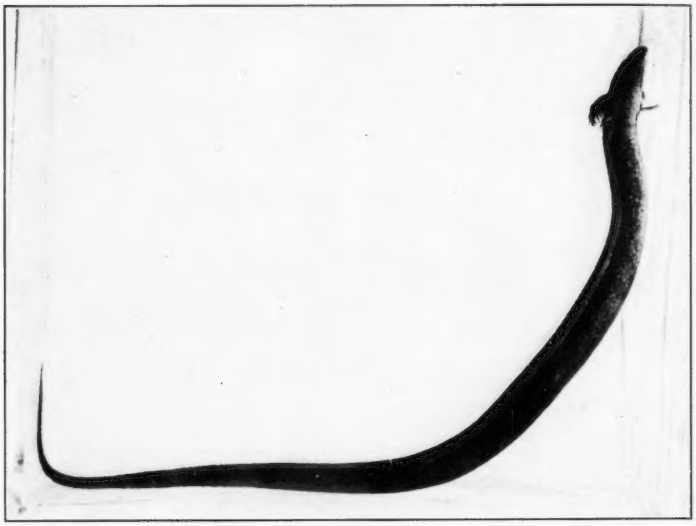

Fig. 3. *Pseudobranchus striatus*, 159 mm. (U. S. N. M. No. 84610.) Chesser's Island, Okefinokee Swamp, Ga. July 20, 1931.

Cope (1889, p. 232) lists four specimens in the U. S. National Museum from "Georgia," collected on Feb. 1, 1851, and received from Dr. W. L. Jones, who was a friend of the Le Contes. Fowler and Dunn record (1917, p. 7) "four from Georgia (Major Le Conte and Dr. W. L. Jones)" in the collection of the Philadelphia Academy. In three successive editions of their "Check List" (1917, p. 24; 1923, p. 21; 1933, p. 24), Stejneger and Barbour remark concerning the type locality: "Not given, but by inference it was one of the Le Conte plantations in Floyd or Liberty Co., Georgia." There is no apparent explanation for the inclusion of Floyd County in this statement, for it lies in northwestern Georgia, over 200 miles from Liberty County.

There seems to be sufficient justification for hereby formally restricting the type locality to the vicinity of Riceborough, Liberty County, Georgia.

Bufo americanus americanus Holbrook. AMERICAN TOAD

North Carolina.—At Bryson City, Swain County (alt. 1800 ft.), several were heard at dusk on May 3, 1933 (estimated temp. 60°F.); and at Elk

Park, Avery County (alt. 3200 ft.), one was heard during the following evening (est. temp. 58°).

At Banner's Elk, Avery County (alt. 3700 ft.), during the evening of May 23, 1934 (temp. 58°), about ten were actively moving about and trilling in a meadow pool. The trills lasted generally about 4, 5, or 6 seconds; there was one record of 14 seconds. The average duration of the trills was much

Fig. 4. *Bufo americanus americanus*, trilling, at a fountain pool. Frogtown Gap, Lumpkin-Union county boundary, Ga. June 6, 1934 (10:58 p.m.).

shorter here than I have noted elsewhere. Two males (75 and 78 mm.) collected here are noteworthy for their robust development of body and limbs. Their drab ground color, however, scarcely accords with the "saturated coloration" ascribed by Rhoads (1895, p. 396) to specimens from near-by Roan Mountain.

Georgia.—From June 2 to 6, 1934, several of these toads were noted trilling at night about a rock-built fountain at Frogtown Gap[2] (3108 ft.), at the Lumpkin-Union county boundary (Fig. 4). Two trills lasted 10 and 11 seconds. There were tiny tadpoles in the fountain on June 2. A 75-mm. male was collected here. A 40-mm. specimen was taken on June 2 on an open, grassy slope close to the summit of Blood Mountain in Union County (alt. 4440 ft.); even at this immature stage there are minute horny pustules

[2] In recent years this name has been changed to Neel's Gap, but the older name still appears on the Dahlonega quadrangle, issued by the U. S. Geological Survey, and it is retained here for convenience in locating it on this map.

on the ventral areolae. This is probably the highest recorded altitude for the species in Georgia. As a matter of fact, there seems to have been a marked dearth of definite and detailed records for it anywhere in the state.

While *Bufo fowleri* doubtless occurs throughout the Piedmont of Georgia, almost the entire problem of the distribution of the other two species *(americanus* and *terrestris)* in this region remains to be worked out. It will very likely be found that their ranges do not overlap; in fact, that of *terrestris* may not extend appreciably north of the Fall Line.

Tennessee.—During the evening of June 19, 1934 (temp. 59°), there was some very desultory calling on the part of three of these toads in a boggy meadow along the Little Pigeon River near Gatlinburg, Sevier County (alt. 1400 ft.). Nine trills lasted from 6 to 9 seconds each (average, 7.5).

Bufo fowleri Hinckley. FOWLER'S TOAD

The occurrence of this species on various coastal islands, such as Muskeget Island, Mass., Long Island, N. Y., and Long Beach Island, N. J., to the exclusion of *B. a. americanus*, suggests that it was resident along the Atlantic Coast before these islands became separated from the mainland (presumably during the Pleistocene), whereas *americanus* must not have reached the coast until some later period.

Calling males of the present species exhibit a narrow but conspicuous light streak along the margin of the lower jaw, in contrast with the dark vocal sac. Photographs of calling males of *B. a. americanus* and *B. terrestris* reveal such a character less conspicuously or not at all. The inflated sacs of the last two (Figs. 4, 7) are of approximately the same shape, but that of *fowleri* protrudes relatively farther and has more of an upward thrust (Fig. 6; cf. also Overton, 1914, pl. 3, and Harper, 1928, p. 6, fig.).

Specimens of *fowleri* from Massachusetts, New York, New Jersey, Pennsylvania, Delaware, Kentucky, and Georgia have the parotoids very nearly or quite in contact with the postorbital ridges; in an occasional specimen the two structures are actually coalescent. There is little or no indication of a supratympanic ridge in any of the specimens, such as is evident in *americanus* and *terrestris*.

Comparison of these and other structural characters, as well as of voices, emphasizes the rather close relationships of *americanus* and *terrestris* and the distinctness of *fowleri*.

North Carolina.—A Fowler's Toad was heard at dusk on May 3, 1933, at Bryson City, Swain County.

Georgia.—Half a dozen were calling on dry land about a bathing pool at Harlem, Columbia County, during the evening of June 28, 1931 (est. temp. 85°). The beginnings of an individual's calls were about 5 seconds apart, and the duration of each call was about 1½ seconds. Another Fowler's Toad was seen the following day at Litner's Pond, Richmond County. On May 28, 1934, a 57-mm. male was collected in woods of *Quercus marylandica* 5 miles west of Philomath, Oglethorpe County.

After finding that *B. a. americanus* is apparently the only representative of the genus at Frogtown Gap and Blood Mountain, it was surprising to en-

counter only *fowleri* on Tray Mountain, in rather damp oak woods along the Towns-Habersham county boundary (alt. 4250-4260 ft.). This is just one of several interesting faunal and floral differences between Tray and Blood Mountains, both of nearly equal height and only 15 miles apart.) Two of the toads (Fig. 5) were rustling among the leaves after dark on June 11, 1934, and another was abroad during the cloudy and drizzly afternoon of June 12. A specimen was taken on each date; both are adult females (58 and 66 mm.). This spot is quite possibly the highest elevation at which the species has ever been recorded.

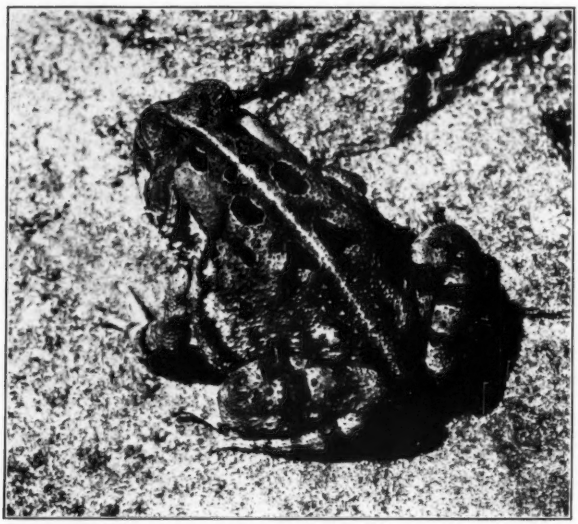

Fig. 5. *Bufo fowleri*, adult female, 58 mm., posed on a stone. (F. H. No. 306.) Tray Mountain, Habersham-Towns county boundary, Ga. June 13, 1934.

The two specimens are distinguished by their rather light, more or less pinkish ground color, in sharp contrast with the comparatively few dark dorsal spots and the cross-bars on the limbs. Each has a dark mid-pectoral spot, and one has in addition smaller spots along the lower jaw and the sides of the breast. The tibiae are 42.2 and 43.2 per cent, and the whole hind feet 65.5 and 63.6 per cent, of the length (snout-vent). The areolae of the under parts are without horny pustules. The parotoids are in contact with the postorbital ridge.

On June 14, 1934 (temp. 66° at 11.45 p. m.), at Blue Ridge, Fannin County (alt. 1750 ft.), a chorus began toward dusk and continued for at least four hours, though the vigor of the calling waned progressively. About ten individuals were heard along the grassy bank of a ditch beside the rail-

road. The intervals between the beginnings of 20 consecutive calls of a 57.5-mm. individual (Fig. 6) ranged from 6 to 14 seconds (average, 9.4). At one time there was a general hush in the chorus of near-by toads; it was as if by general agreement, and yet without any evident cause.

Fig. 6. *Bufo fowleri*, 57.5 mm., squawking, on the grassy bank of a ditch. (F. H. No. 309.) Blue Ridge, Fannin County, Ga. June 14, 1934 (11:04 p.m., E. T.).

On June 15, 1934, several were heard near Cisco and Eton and at Chatsworth—all in Murray County. On the following evening one was heard at Calhoun, Gordon County.

Tennessee.—During the showery evening of June 17, 1934 (temp. 77°), at Etowah, McMinn County, a considerable number of these toads were heard. As well as I could judge, the calls generally lasted about 1½ seconds, the extremes ranging from about 1 or 1¼ to 1⅔ seconds. The intervals between the beginnings of 11 consecutive calls of one individual seemed to range from 5 to 11 seconds (average, 6.2). At Gatlinburg, Sevier County (alt. 1350 ft.), several were heard at dusk on June 18.

Kentucky.—At Cumberland Falls, McCreary County (alt. 875 ft.), during the evenings of June 20 and 21, 1934 (temp. 68° and 74°), Fowler's

Toads furnished the dominant amphibian voice. They fairly swarmed over the roadway at dusk, and filled the night air with their banshees' wailing, repeated over and over in an almost continuous chorus. They congregated along the river bank, evidently finding here and there some quiet water in which to breed.

During the morning of June 21 a 53-mm. female was routed from a bed of sand near the river bank. It was completely out of sight beneath a slight depression that had the appearance of being a doodle-bug's *(Myrmeleon)* pit. Numbers of transformed toads (presumably *fowleri)* were hopping over paths in the woods. Adults were also met with by day in the woods. They seemed to hop in a more lively manner than *americanus;* perhaps this superior agility befits their lighter build.

Louisiana.—Several were heard on the banks of the Mississippi near New Orleans during the evening of July 2, 1929. The calls lasted about 1½ seconds each.

Bufo quercicus Holbrook. Oak Toad

Burt's remark (1932, p. 78) concerning this species, "At night it is heard rather frequently from trees in certain areas of the Southeast," would seem to require explanation, for an arboreal habitat for *Bufo quercicus* is something previously unheard-of.

North Carolina.—At 8:55 and 9:15 p. m. on July 26, 1931, the shrill peeping of this species was heard abundantly from a northbound Atlantic Coast Line train that had left Florence, S. C., about 8. p. m. The localities were probably in Robeson County, N. C.

Georgia.—During the rainy evening of June 11, 1922, many were heard at various places in Wayne and Pierce Counties between Jesup and Waycross. One was noted on April 8, 1933, between Cox and Fort Barrington, McIntosh County, near the type locality of the long-lost tree *Franklinia alatamaha;* another on April 30, 1933, on an "oak ridge" near Alma, Bacon County.

The species is rather common in the intermediate pine barrens about Suwannee Lake, Ware County, and during the dry month of July, 1931, it was even found invading the bordering creek swamp and occasionally indulging there in its diurnal vocal performance.

When several rather dry seasons culminated in the severe drought and widespread fires of April, 1932, in the Okefinokee region, I heard not a single Oak Toad's voice and noted not more than one individual during several weeks of this month. But subsequent heavy rains evidently gave the species a very successful breeding season, and by April of 1933 it appeared fully as common as ever. It was in voice by the night of April 9 (temp. 64° at 11:10 p. m.), and again on April 10, 20, and 26. These are my earliest vocal records for the region. On the afternoon of the 10th, while walking through a small area in the pine barrens of Charlton County a couple of miles east of Chesser's Island, where a severe fire had swept just a year previously, I encountered an Oak Toad about every rod. Most of the individuals observed during this month, however, were noticeably small—say from 16 to 22 mm. in length;

probably the majority of these represented the previous season's hatching. Four collected at random near Suwannee Lake on April 27 measure 17.5, 18, 19, and 21 mm.

In my first encounter with the species in 1921 I noticed (1931a, p. 177) its interest in ants. Confirmatory observations were made on an individual brought alive from Georgia in April, 1933, and kept in Swarthmore, Pa. Small ants introduced into the terrarium were promptly taken, but aphids apparently were not accepted. When placed outdoors on a flagstone where many small ants were moving about, the toad would take notice of an ant's approach, and when it had arrived with half an inch or so, there would be a lightninglike flick of the toad's tongue, and the ant would be simply gone! Meanwhile the toad's body seemed to remain almost motionless, with little or no sign of swallowing. This individual maintained itself for about two months on a more or less exclusive diet of ants.

Mississippi.—During the evening of September 1, 1929, many were heard from a train in the general vicinity of Bay St. Louis or Pass Christian. This is my latest record of vocal activity.

Bufo terrestris (Bonnaterre). SOUTHERN TOAD

As Deckert (1914, p. 2) has pointed out, this species is shorter-limbed than *B. a. americanus*. In four adult males (62.5-78 mm.) of *americanus* (two from Banner's Elk, N. C., one from Frogtown Gap, Ga., and one from Morgan, Vt.), the tibial length is 40 to 41.7 per cent, and the whole hind foot is 65.3 to 67.2 per cent, of the body length (snout-vent). In two adult males (64.5-70 mm.) of *terrestris* from Bayport, Fla., the tibial length is 36.4 to 38.8 per cent, and the whole hind foot is 58.6 to 62 per cent, of the body length. Subadult individuals have relatively longer hind limbs than old adults. The snout of *terrestris* is distinctly more pointed than that of *americanus*. Both species have horny pustules on the areolae of the under parts. The number of enlarged warts in each of the larger dorsal blotches is frequently three or more in *terrestris*, but generally less than three in *americanus*. The parotoid is more distinctly and regularly separated from the postorbital ridge in *terrestris* than in *americanus*. The toes of both of these species appear, in general, a little more fully webbed than those of *fowleri*.

North Carolina.—At Edenton, Chowan County, during the evening of April 3, 1933 (est. temp. 60°), there was a general chorus of *Bufo*. Some of the toads were audible at a distance of about half a mile, and the note sounded almost deep enough for *terrestris*. Yet others close at hand gave a more gentle trill much like that of *americanus*. I recorded a number of trills of one individual, with lengths in seconds approximately as follows: 22, 21, 11, 10, 13, 9, 12, and 16. The average duration (14.3 seconds) was considerably longer than I have ever recorded for *terrestris* in Georgia. A 56-mm. male, with breeding pads on the thumbs, was collected; it was apparently the one that had been giving the long trills. Although by its voice I judged it to be *americanus*, yet by its structural characters it must be referred to *terrestris*. Its cranial ridges, though not so strongly developed as in larger individuals, are of the *terrestris* type, ending posteriorly in curved knobs; the parotoids

are well separated from the postorbital ridges; the warts on the back and on the tibiae are not greatly enlarged; the snout is pointed like that of typical *terrestris;* and the under parts are very nearly unspotted.

It is interesting to find this eastern North Carolina population approaching *americanus* so closely in voice, while retaining the structural characters of *terrestris*. It suggests the possibility that the two forms intergrade as subspecies.

Georgia.—During the evening of April 6, 1933, a number were seen in a road near the Savannah River just below the city of Savannah. They were probably on their way to join several species of frogs calling in a near-by pool. On April 30, 1933, the species was noted 7 miles south of Alma in Bacon County, and in the Altamaha River swamp in Toombs County. Here one individual was in a hole in the mud at the immediate edge of a pool, with only its head projecting. On the same date, at night, the species was in

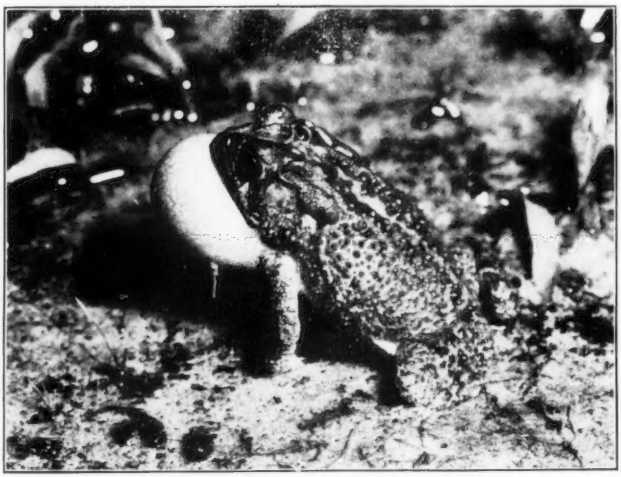

Fig. 7. *Bufo terrestris*, roaring, at a rain puddle in a cultivated field. Chesser's Island, Okefinokee Swamp, Ga. April 15, 1933 (9:20 p.m.).

voice along the Ohoopee River several miles southwest of Reidsville, Tattnall County.

Of two females (74.5 and 76 mm.) received from William B. Harper in 1933, at least one was drawn up out of a well in Harlem, Columbia County; the other was obtained either in the same place and manner or from half a dozen miles northwest of Augusta, Richmond County.

Columbia County is apparently one of the most northerly areas in the state from which *B. terrestris* has been recorded. There is no evidence that Allard's record (1908, p. 655) of "*Bufo lentiginosus*" from Gwinnett or Jackson Counties was based upon critically determined specimens. There is

an amazing dearth of definite records of Salientia in Georgia above the Fall Line.

Pseudacris nigrita nigrita (Le Conte). LE CONTE'S CHORUS FROG

Georgia.—Generally dry weather in the Okefinokee region in May, 1930, July, 1931, and April, 1932, apparently kept this species in silence. But conditions were vastly different in April, 1933, when abundant rains and high water prevailed. During continuous rain on the afternoon of April 9 the weather was so cool (est. temp. 58°-60°) that this species and *P. ocularis* were the

Fig. 8. *Pseudacris nigrita nigrita*, 29.5 mm., trilling, in a grassy, rain-flooded flat. (F. H. No. 180.) About 3 miles west of Folkston, Charlton County, Ga. April 9, 1933 (10:15 p.m.).

only amphibians heard in the entire 35 miles between Waycross and Folkston. *P. n. nigrita* was trilling at several places a few miles north of Folkston.

During the evening of the same day (temp. 64° at 11:10 p. m.) about half a dozen individuals were trilling in a grassy, rain-flooded flat near Spanish Creek about 3 miles west of Folkston. This early-breeding species was now far less shy than I had found it in the same locality in June, 1929, when its mating ardor had presumably subsided somewhat (1931b, p. 161). Consequently I was enabled for the first time to secure flashlight photographs of the trilling performance (Fig. 8). The rate of calling was recorded as follows: 13 times in 30 seconds (two records), and 6 times in 15 seconds. This rate (24 to 26 times per minute) is slower than I recorded during somewhat warmer weather in June (30 to 38 times per minute). The trills on this occasion seemed to consist of 5 or 6 notes.

Colors of two males taken here (27 and 29.5 mm.) were noted in life as

follows: pale olive above, with three rows of black spots; limbs black, with fine crossbars of white or pale cream; maxillary streak white; throat dusky orange; ventral side of femur pale lemon or straw color. Though evidently not of arboreal habit, they were able to ascend the vertical side of a glass aquarium jar.

Prior to 1933 there had been no record of this frog from within the borders of Okefinokee Swamp. This now appears to have been due to lack of observation during the main breeding period in winter or early spring, for the trilling was noted on Chesser's Island on April 10, 11, and 15. On April 11, about 10:25 p. m. (est. temp. 64°-65°), the rate of calling was 17 to 18 times in 30 seconds. Three periods of calling lasted for about 45, 45, and 30 seconds.

Although I once indicated (1931b, p. 161) a preference for "Black Chorus Frog" among the common names employed up to that time, I now propose "Le Conte's Chorus Frog" as a more appropriate appellation for this elusive and fascinating little creature.

In his type description of *Rana nigrita*, John Eatton Le Conte gave (1825, p. 282) no indication of its range, but eventually he remarked (1855, p. 427) that it "inhabits Georgia and S. Carolina." In the meantime Holbrook had very definitely stated (1838, ed. 1, vol. 3, p. 94): "This animal has as yet only been found in Georgia and Carolina. Leconte observed it in the former state, and I have seen it in the latter." Furthermore, Duméril and Bibron had remarked (1841, vol. 8, p. 509), under the name of *Acris nigrita:* "Cette espèce nous a été donnée par M. Leconte, qui l'a trouvée en Géorgie." It is fairly evident from the foregoing that Le Conte knew the species originally only from Georgia, and in all likelihood he made its acquaintance on the Le Conte plantation. Consequently the type locality is hereby restricted to the vicinity of Riceborough, Liberty County, Georgia. Cope (1889, p. 339) lists two specimens from Liberty County, received from Dr. J. L. Le Conte (no date).

Pseudacris nigrita feriarum (Baird). Eastern Chorus Frog

North Carolina.—On April 4, 1933, a *Pseudacris* of the *nigrita* group was heard in a sphagnous swamp in Beaufort County, 7 miles north of Vanceboro. The identification as subspecies *feriarum* rather than *nigrita* is on purely geographical grounds, since the voices of the two forms have so far remained indistinguishable to me. Of *P. brimleyi*, described from this same county, Brandt and Walker say (1933, p. 3) that in voice it "is not to be confused with any of its congeners in the southeast."

Pseudacris ocularis (Holbrook). Little Chorus Frog

North Carolina.—During the rainy evening of July 26, 1931, I heard, from an Atlantic Coast Line train, numerous individuals at two localities that were probably in Robeson County.

On the afternoon of April 2, 1933, at a tree-dotted pond just north of Powell's Point, Currituck County, I heard the apparently unmistakable notes of this species from about two individuals. If the record should eventually be verified, it would evidently constitute the northeasternmost one to date for the species.

Georgia.—During the evening of June 11, 1922, a few were heard at two places between Jesup and Screven. While traveling by rail during the evening of September 17, 1922, I heard the insectlike voice of this species quite commonly at several places in Pierce and Wayne Counties, between Waycross and Jesup. This is my latest record of vocal activity.

On April 25, 1932, one was heard 4 miles south of Oak Park, Emanuel County. On April 30, 1933, the species was noted at five points along U. S. Route 1—two near the Satilla River, Ware County, and three in Bacon County up to its northern boundary at Satilla Creek.

Florida.—The Academy of Natural Sciences of Philadelphia has a 10.5-mm. specimen (No. 18040) from Key West, collected by Morgan Hebard in March, 1910. This is evidently the southernmost point from which the species has been, or is likely to be, recorded.

Hyla avivoca Viosca. BIRD-VOICED TREE-FROG

Georgia.—This species was noted for the first time in Georgia in April, 1932 (Harper, 1933). A year later I had the good fortune to find it in vocal activity not only at the two stations of 1932 but also at three additional stations. It is now known within the state from the swamps of the Ogeechee, Ohoopee, and Altamaha Rivers.

All five stations are included between the Fall Line on the northwest and the boundary between the Altamaha Grit Region (or rolling wire-grass country) and the Flat Pine Lands on the southeast (cf. R. M. Harper, 1906, pp. 18-20 and frontispiece; 1930, p. 6). Evidence continues to accumulate that this boundary may be one of some importance in zoögeography, and it is quite possible that *Hyla avivoca* may be limited by it in its distribution toward the Atlantic Coast.

At each of the five stations for this species, except the middle one on the Ohoopee River, *Hyla versicolor versicolor* also was recorded in voice, at various dates between April 25 and May 2. Evidently both of these species, so remarkably similar in appearance, have the same habitat preferences. But the absence of *avivova* from the Flat Pine Lands is suggested by failure to hear it at various points in this region where I have found *versicolor* in voice (Satilla and St. Mary's Rivers and Spanish Creek).

About 4 o'clock on the hot and sunny afternoon of April 30, 1933, the present species was heard over a sizeable area in the big river swamp on the north side of the Altamaha in Toombs County, along U. S. Route 1. A number would call at the same time, forming a continuous chorus, and then all would be silent for a considerable period.

About 6:15 p. m. of the same day several more were heard on the east

side of the Ohoopee River at Shepard's Bridge, Tattnall County, 4 miles southwest of Reidsville. Although I had hoped to find the species here, yet at the first moment of hearing the loud, birdlike call, I wondered what bird could be the author of it.

After dark I located two individuals in this area. Their habitat was a small bayou (Fig. 9) communicating directly with the river about a hundred yards north of the road. In the shallow borders of the bayou stands a thick growth of tupelo *(Nyssa ogeche)*, cypress, willow, ash, buttonbush *(Cephalanthus)*,

Fig. 9. Habitat of *Hyla avivoca*. A bayou on the Ohoopee River 4 miles southwest of Reidsville, Tattnall County, Ga. Principal vegetation: river cypress *(Taxodium distichum)*, tupelo *(Nyssa ogeche)*, *Ilex amelanchier*, *Smilax* sp., and *Nymphaea (fluviatilis?)*. May 1, 1933.

tyty *(Cyrilla racemiflora)*, and a rare and a little-known shrub, *Ilex amelanchier* (found here in flower). The open water in the middle is occupied in part by *Nymphaea* (presumably *fluviatilis)*.

The first individual encountered was among some shrubs or small trees, at a distance of perhaps 10 or 12 feet from shore and at a height of about 4 feet above the water. The other was perching at first at a height of about 5 feet on a nearly horizontal limb of a *Cyrilla* growing at the water's edge. It was one of the most accommodating frogs I have ever photographed, allowing me to remove twigs and shrubs from about it and even to touch it with twigs.

Fig. 10. *Hyla avivoca*, 33 mm., trilling, on a nearly vertical dead shrub at the edge of a bayou. (F. H. No. 200.) Ohoopee River, 4 miles southwest of Reidsville, Tattnall County, Ga. April 30, 1933 (10:18 p.m.).

After a time it moved to a vertical position a few inches higher up on a dead shrub (Fig. 10). During part of its stay at this second position it turned sideways in much the same attitude as that figured by Viosca (1928, pl. 11, fig. 2). It may have turned thus to avoid the glare of my electric torch.

About 10:25 p. m., with the temperature in the neighborhood of 75°-78°, I timed 20 consecutive calls of this individual, measuring them roughly with the second hand of my watch. The calling periods varied from 3 to 6 seconds, averaging 4.1 seconds. The number of notes *(wit-wit-wit,* etc.) in a series was generally in the neighborhood of 20; thus they were uttered at the approximate rate of 5 per second. The 19 intervals between the calls varied from 6.5 to 47 seconds. If we omit the three longest of these intervals—

47, 38, and 21.5 seconds—as perhaps not normal, the remaining 16 varied from 6.5 to 14 seconds, and averaged 9.4 seconds.

Although the brief experience in 1932 led me to conclude that "the notes were delivered just a bit too slowly . . . to constitute an actual trill," I would now characterize the call as a slow trill. At least it has about as much claim to this characterization as the song of the Chipping Sparrow has.

At the maximum inflation of the vocal sac, its diameter appears approximately equal to the width of the body and to half the length of the body without the head. In the fraction of a second between consecutive notes it is deflated to about half the maximum size; and during the silent intervals between calls to about one-quarter of the maximum size.

At one time the individual photographed gave a different and much shorter call than the birdlike trill of *wit-wit-wit*, etc. It consisted of about two shrill, cricketlike, trilled notes—*c-r-r-r-e-e, c-r-r-r-e-e*—a little suggestive of the occasional trilled note *(p-r-r-r-e-e-p)* of *Hyla crucifer*. The same sort of note was heard on the following day along the Ohoopee in Emanuel County. Viosca (1928, p. 90) has already called attention to such a note being uttered in Louisiana.

On May 1, in this same area, an individual called at 1:30 p. m. There were bright clouds at the time, and the temperature was about 80°. About 4 p. m. another was heard in the swamp on the west side of the Ohoopee River near Ohoopee, Toombs County. Between 5 and 6 p. m., along the same river about 4 miles north of Oak Park, Emanuel County, *Hyla avivoca* was heard in numbers. Evidently it is a very characteristic species of the Ohoopee River swamps.

Finally, on May 2, an individual was heard about 2 miles south of Louisville, Jefferson County, in the Ogeechee River swamp. The time was about 9:50 a. m.; the sun was bright, and the temperature was estimated at 73°. This area was the same one in which I had found a number calling on the night of April 25, 1932. I now noted the trees of this part of the swamp as cypress, sweet gum, black gum, and ash.

The diurnal vocal activity recorded at each of the five stations, in sunny weather, suggests that the calling and breeding season may be in full swing in late April and early May.

The call is quite noteworthy in quality and volume; it is much more birdlike than froglike, and would be audible at a distance of perhaps 400 yards. Probably almost any layman, on having his attention drawn to the sound, would pronounce it that of a bird. It even suggests to me the "winnowing" sound of Wilson's Snipe. It is decidedly the pleasantest frog voice I know.

A slight character, helping to distinguish this species from *Hyla versicolor versicolor*, and holding in a great majority of specimens, is the shape of the white blotch beneath the posterior half of the eye. In *avivoca* the anterior border generally slants obliquely forward from the eye to the mouth; in *versicolor* it generally slants obliquely backward, but occasionally is more or less vertical, and rarely slants forward.

Hyla cinerea cinerea (Schneider). GREEN TREE-FROG

South Carolina.—On April 6, 1933, one was heard in the Santee River swamp in Berkeley County north of St. Stephen. This is my earliest record of vocal activity.

Georgia.—During the evening of June 28, 1931 (est. temp. 85°), several were calling vigorously about a bathing pool at Harlem, Columbia County, notwithstanding the prevalence of a severe drought. This is apparently the northernmost record for the state. The locality is at the extreme inner edge of the Coastal Plain, to which the species is virtually limited.

Hyla crucifer Wied. SPRING PEEPER

North Carolina.—In 1932 single individuals were heard near Rhems, Craven County, on April 3, and 5 miles north of Rockingham, Richmond County, on April 27. In 1933 numbers were heard at Edenton, Chowan County, on April 3, and near Etna, Macon County, on May 3.

At Bryson City, Swain County (alt. 1800 ft.), two males (24.5 and 22 mm.) were collected during the evening of May 3, 1933, while calling in a rather desultory fashion at a little distance from the water: one on a shrub a foot above the ground, and the other on grass stems. During the next evening (est. temp. 58°), at Elk Park, Avery County (alt. 3200 ft.), Peepers were heard at several wet meadows. The rate was recorded as follows, from two different individuals: 12 times in 12 seconds, 30 times in 22 seconds, and 16 times in 15 seconds. At its maximum inflation the vocal sac was about as large as the body (without head) when the lungs, in their turn, were inflated. Between peeps the sac was deflated to about half its maximum size. The two males seen here appeared considerably darker as well as larger than those from the lower altitude at Bryson City; one collected is 28 mm. in length.

During the rainy evening of May 22, 1934 (est. temp. 60°), several were heard at West Jefferson, Ashe County (alt. 3100 ft.). During the following evening (temp. 58°) numbers were calling desultorily in a wet meadow at Banner's Elk, Avery County (alt. 3700 ft.), and two males (28 and 25.5 mm.) were collected. On May 24 two were heard near Marion, McDowell County.

Seven males from elevations of 2250 to 6300 feet in the Appalachian region (two from Garrett County, Md.; three from Avery County and one from Mitchell County, N. C.; one from Union County, Ga.) have, on the average, distinctly more robust bodies and longer limbs than five males from near sea level (four from Accomac County, Va.; one from Delaware County, Pa.). The average measurements of the two lots are, respectively, as follows: snout to vent, 26.7, 26.4 mm.; tibia, 13.6, 13; whole hind foot, 20.1, 17.7; intertympanic width, 8.2, 8.1; elbow to tip of third finger, 13, 11.9; interolecranal extent (distance between elbows when humeri are extended in the same line at right angles to longitudinal axis of body), 17.8, 16.3; intergenual extent (distance between knees when femora are extended in the same line at right angles to longitudinal axis of body), 24.7, 23.7. These differences in measurements, while fairly small, are doubtless of some zoögeographical

significance. Yet it is questionable whether it would be worth while to give nomenclatural recognition to an Appalachian form of *Hyla crucifer*.

In this connection it may be recalled that environmental influences have produced a number of distinct, geographically representative forms in the higher mountains of North Carolina and adjacent states, such as *Sciurus hudsonicus abieticola* Howell, *Evotomys carolinensis* Merriam, *Dendroica caerulescens cairnsi* Coues, and *Junco hyemalis carolinensis* Brewster. The chief factors involved appear to be higher humidity and lower temperature, as compared with conditions in the less elevated surrounding areas. The heavy precipitation and frequent fogs have been commented upon by Rhoads (1895, p. 380) and by Howell (1929, p. 75). The four above-mentioned Appalachian forms (two mammals and two birds) are all characterized by darker coloration and larger size than are their nearest geographical representatives. Rhoads (1895, pp. 395, 396) also distinguishes *Rana clamitans melanota* (Raf.) of Roan Mountain—"a large dark, shagreened Spring-frog"—from *R. clamitans* Latr. of the lowlands, and refers to "the large size and saturated coloration" of *Bufo americanus* from Roan Mountain. The Roan Mountain Jumping Mouse, *Napaeozapus insignis roanensis* (Preble), is darker, but on the other hand smaller, than *N. i. insignis* (Miller).

Rhoads's specimen of *Hyla crucifer* (No. 4391, Acad. Nat. Sci. Philadelphia) from an elevation of 6300 feet on Roan Mountain, Mitchell County, probably furnishes the highest altitudinal record of the species to date.

Georgia.—Toward dusk on June 7, 1934, one or two were heard and a 25.5-mm. male was collected in Union County about 2 miles northeast of Frogtown Gap (alt. 2400 ft.).

Florida.—In 1917 I recorded the voice of this species (with a query) at McIntosh, Marion County, on February 16, and at Fernandina, Nassau County, on February 26. At the latter point it seemed to me "exactly the right note" for *Hyla crucifer*. Yet it is just possible that one or both of these records may refer to *Pseudacris ornata*. I have never identified the voice of this species, which is described as similar to that of *H. crucifer* by Allen (1932, p. 7) and by Deckert (1915b, p. 22, under the name of *Chorophilus occidentalis*). *Hyla crucifer* is reported by Deckert (1915a, p. 3) from the vicinity of Jacksonville, and by Van Hyning (1933, p. 4) from Alachua County.

Tennessee.—During the evening of June 19, 1934 (temp. 59°), a number were calling in a boggy meadow 1½ miles southwest of Gatlinburg, Sevier County (alt. 1400 ft.). Both the single *peep* and the rolling *p-r-r-r-e-e-p* were heard here.

Kentucky.—At dusk on June 20, 1934, one was heard at Cumberland Falls, McCreary County.

Hyla femoralis Latreille. PINE-WOODS TREE-FROG

Georgia.—My earliest record of vocal activity on the part of this species is April 10, 1933, when an individual was heard near Folkston, Charlton County. In spite of plentiful rain, only a few sporadic calls were heard during the remainder of the month in the Okefinokee region; and these were from

the trees, not from the breeding ponds. In the hammock on Chesser's Island one of these frogs had established its quarters beneath a dead live-oak leaf that had become caught in a crack of a dead saw-palmetto fan about a yard above the ground (Fig. 11). During the period from April 10 to 24 it was noted as present in this position on seven days, and as absent on two or three occasions (one of these being at night). Perhaps it stirred abroad to feed during the hours of darkness. Ordinarily its color was a very pale, nearly uniform brown like that of the palmetto fan, but during rain it became much

Fig. 11. *Hyla femoralis*, adult, in a habitual diurnal retreat, behind a dead live-oak leaf on a dead saw-palmetto fan. Chesser's Island, Okefinokee Swamp, Ga. April 22, 1933.

darker. Ben Chesser spoke of finding as many as three or four of these frogs beneath one piece of bark, while cutting timber in the cypress bay surrounding Chesser's Island. This was probably in winter, and gives a clue to the hibernating habitat of the species (cf. Allen, 1932, p. 8).

At Suwannee Lake, Ware County, on April 26, two of these frogs appeared on the porch of an old cabin, where some winged ants were in evidence. As one crawled and hopped along, it was seen to pick up something like an ant. One would also make a leap of 6 inches or so, probably snapping up an ant at the end of the leap.

At a roadside pond several miles southwest of Reidsville, Tattnall County, some of these frogs were heard during the night of April 30, 1933.

Hyla squirella Latreille. SOUTHERN TREE-FROG

North Carolina.—During the afternoon of April 3, 1933, one was heard at a pond near Powell's Point, Currituck County; and during the evening of the same day several were heard at Edenton, Chowan County. The species was heard at noon the next day in a sphagnous bog in Beaufort County, 7 miles north of Vanceboro.

South Carolina.—On April 6, 1933, one was heard in the Santee River swamp north of St. Stephen, in Berkeley County.

Georgia.—On September 17, 1922, several were heard at night at Offerman, Pierce County. On May 2, 1933, one was heard in the Ogeechee River swamp south of Louisville, Jefferson County.

Mississippi.—During the rainy evening of September 1, 1929, many were heard from a train in the vicinity of Bay St. Louis or Pass Christian.

Hyla versicolor versicolor LE CONTE. COMMON TREE-TOAD

Most of the following records of this species indicate that it is partial to the wooded banks of streams and ponds.

North Carolina.—On April 2, 1933, I heard several at a pond near Powell's Point and one near Mamie, Currituck County. On the same afternoon numbers were heard near woodland pools among old sand dunes in the vicinity of Kitty Hawk, Currituck County, and on the following day one was heard among wooded dunes north of Nag's Head, Dare County.

South Carolina.—On April 6, 1933, one was heard near St. Stephen. Berkeley County.

Georgia.—During the rainy evening of June 8, 1929, several were heard in the vicinity of Spanish Creek several miles west of Folkston, Charlton County. On April 9, 1933, one was heard along the Satilla River near Atkinson, Brantley County, and one on the following day near Spanish Creek southwest of Folkston. On April 30, 1933, several were heard in the Altamaha River swamp in Toombs County; on the following day one was heard along the Ohoopee River southwest of Reidsville, Tattnall County, and several along the same river north of Oak Park in Emanuel County.

Hyla versicolor is the common frog in the mountains of Lumpkin and Union Counties, on both sides of Frogtown Gap (alt. 3108 ft.). It is difficult to figure out where it finds suitable breeding places here, unless in the side pools of the mountain streams. It was in good voice from June 1 to 9, 1934, being heard to some extent during the day, but calling more steadily after dark. The highest elevation at which I heard it calling was 3500 feet on Blood Mountain, Union County; lower elevations were 1900 feet at Blairsville, Union County, and 2400 feet between Presley and Mountain Scene, Towns County.

At dusk on June 2 I timed the trills of an individual in an oak at Frogtown Gap. The intervals between the beginnings of 11 consecutive trills varied from 5 to 7 seconds (average, 6.3). On the rainy evening of June 5, at a little artificial fountain pool which attracted the tree-toads, one would start calling immediately after a near-by *Bufo a. americanus* would. Its dark throat remained partly inflated during an inactive period. On both of these evenings the temperature was probably close to 65°.

Several tree-toads were heard at Blue Ridge, Fannin County (alt. 1750 ft.), during the evening of June 14, 1934 (temp. 66°), and others at Chatsworth, Murray County (alt. 800 ft.), on the following evening. At these two places, and also at Etowah, Tenn., the calls seemed to lack vigor and to

be rather short, compared with those in the mountains. At Chatsworth each call lasted about ⅔ second: *c-r-r-r-r-r.*

Tennessee.—On the rainy evening of June 17, 1934 (temp. 77°), a number were heard and a 37-mm. male was collected at Etowah, McMinn County. On the evenings of June 18 and 19, 1934 (temp. 59° on the 19th), a number were heard in the vicinity of Gatlinburg, Sevier County (alt. 1350-1500 ft.).

Kentucky.—At Cumberland Falls, McCreary County, during fair weather on the evenings of June 20 and 21, 1934 (temp. 68° and 74°), from six to ten of these tree-toads congregated about some small pools on top of a large rock beside the river just above the falls. They were in rather vigorous voice for at least the first hour or two of darkness (Fig. 12). The roar of the falls one or two hundred feet downstream was not such a noticeable and almost oppressive sound as that of three or four of these Hylidae calling simultaneously within a couple of yards of my ears. Their ground color varied from brown to bark gray and pale green. They squatted at or near the edges of the rock pools, in which some of their light-colored tadpoles were seen. On each evening a pair was noted in amplexus; one such pair leaped voluntarily off the rock into space, doubtless falling into the swift current below and perhaps being swept over the falls. Two males (42.5 and 40.5 mm.) were collected.

On June 21 four different individuals called at approximately the same rate. Seventeen different records of these individuals showed that the time required by them for giving 10 consecutive calls varied from 28 to 39 seconds (average, 34.1). For the most part the duration of the calls seemed about ⅔ second. Thus the average silent interval between calls was about 2.7 seconds. When the calling was quite regular, the 10 calls seemed to be given within a space of about 30 seconds; thus a call every 3 seconds may be approximately the normal rate. When the calling was somewhat irregular, a longer time was required.

Overton (1914, pp. 32-33) has described a peculiar "turkey call" of this species as heard on Long Island, N. Y., and Noble (1931, p. 408) has also referred to it. On April 14, 1915, I heard such a note along Massatayun Creek, Nassau County, Long Island, among a chorus of *Hyla crucifer;* again, on April 22, 1926, I heard a similar note from *crucifer* in a pond at Natick, Mass., where I never found *versicolor;* finally, on April 1, 1934, this note was being given by *crucifer* at Swarthmore, Pa. All of my dates are too early for *versicolor,* and I had long been puzzled at hearing only from *crucifer* a note such as others had ascribed to the other species. At Cumberland Falls, however, on the night of June 21, I finally heard the "turkey call" from a group of three somewhat contentious individuals of *versicolor* that were under observation on the rock above the falls. They were not noticed attempting to embrace, but one seemed to give the call while turning about or shifting the direction in which it was facing. This accords more or less with Overton's observation.

It is evident from the foregoing that both *crucifer* and *versicolor* possess a "turkey call," and if there is any difference in this peculiar utterance on the

part of the one and the other species, I have so far failed to distinguish it. Is the call possibly one of sex recognition?

Eleutherodactylus ricordii (Duméril and Bibron).

Florida.—In the latter part of March, 1931, Dr. H. A. Pilsbry, of the Philadelphia Academy, was collecting specimens of several races of the pulmonate grastropod *Liguus* in the hammocks on and about Long Pine Key, Dade County, west of Royal Palm State Park in the southern Everglades. These mollusks were found hibernating under loose bark, mainly of the "wild

Fig. 12. *Hyla versicolor versicolor*, trilling, on a rock beside the Cumberland River. Cumberland Falls, McCreary County, Ky. June 21, 1934 (8:15 p.m., C. T.).

tamarind" *(Lysiloma)*, a small acacialike tree that is common in the hammocks. Many small frogs, apparently all of the same species, were likewise found beneath the loose bark, and showed considerable agility in leaping away to the ground when disturbed. Two specimens were preserved, and proved to be *Eleutherodactylus ricordii*. I am not aware of any previous record of the species showing a preference for this particular habitat niche in Florida.

It is interesting to recall that both the frog and the mollusk occur in Cuba. *Liguus* is regarded by Dr. Pilsbry as having reached Florida during the Pleistocene, probably by means of floating trees. *Eleutherodactylus*, while perhaps a more recent immigrant, may have crossed the Gulf in the same manner.

I am much indebted to Dr. Pilsbry for the opportunity of presenting this note.

Rana catesbeiana Shaw. COMMON BULLFROG

North Carolina.—One was heard at a pond near Powell's Point, Currituck County, on April 2 and 3, 1933.

South Carolina.—On April 5, 1932, a huge Bullfrog was seen in a roadside ditch between Adams Run and the Edisto River, Charleston County. On April 5, 1933, one was heard in the marshes of the Waccamaw River near

Georgetown. On the following day one was heard in the Santee River swamp north of St. Stephen, Berkeley County, and another along the Santee Canal near Monks Corner in the same county.

Georgia.—During or after heavy rain on August 5, 1921, about two were heard at Fargo, Clinch County. As yet the species does not seem to have been recorded from any other locality so close to Okefinokee Swamp, although Burt (1932, p. 81) found it in the same county near Homerville. During the evening of June 11, 1922, single individuals were heard between Jesup and Screven in Wayne County, and near Patterson in Pierce County. On June 28, 1931, one or two were heard at a bathing pool at Harlem, Columbia County. On April 6, 1933, one was heard on the outskirts of Savannah. On April 30, 1933, one was seen in a branch 5 miles north of Alma, Bacon County. During the night of April 30 one was heard in a bayou along the Ohoopee River southwest of Reidsville, Tattnall County. On the following day, at the same place, a good-sized individual gave a yelping *snurp* as it leaped from the shore into the bayou.

Rana clamitans Latreille. GREEN FROG

North Carolina.—One was seen on May 23, 1934, in a meadow at Banner's Elk, Avery County (alt. 3700 ft.).

Georgia.—Along the St. Mary's River in Camden County I heard one at Gum Stump Landing on August 17, and several near Allen's Mill on August 18 and 19, 1921. On June 11, 1922, the species was heard at two localities near Screven, Wayne County. On April 30, 1933, one was heard in Ware County between Waycross and the Satilla River. One was heard on May 27, 1934, at Lexington, Oglethorpe County; another on June 5 half a mile north of Frogtown Gap, in Union County (alt. 2900 ft.). During the evening of June 14 (temp. 66°) one was seen and several were heard along a ditch in Blue Ridge, Fannin County (alt. 1750 ft.).

My earliest record of vocal activity on the part of this species in the Okefinokee region is April 11, 1933, on Chesser's Prairie; my latest, September 5, 1922, on Grand Prairie. For the most part the call seems to be given singly. But during the season of greatest breeding activity (say from the latter part of May through the early part of summer), a series of notes may be uttered. Thus on May 24, 1921, on Billy's Island, I recorded them as *ctung-ctung-ctung-ctung.*[3] During the night of June 16, 1929, in the cypress bay bordering Floyd's Island, there seemed to be a little more of a pause after the first than after the second of three notes: *ctung, ctung-ctung.* Per-

[3] Some of my manuscript notes on southeastern amphibians were utilized by Wright (1931). Those dealing with the voices of *Bufo quercicus, B. terrestris, Pseudacris nigrita, Hyla andersonii, H. cinerea, Rana clamitans, R. sphenocephala* and *R. virgatipes* were copied with varying degrees of inaccuracy, and are not to be accepted verbatim. The original records of the intervals between calls of *Gastrophryne carolinensis* were misinterpreted, and the results presented (pp.460-461) are wholly erroneous. There is also partial misinterpretation of the time records of the calls of *Bufo terrestris* (p. 141) and of *Pseudacris ocularis* (p. 214).

haps the first note was also more emphatic. On the following day, in the same area, the note sounded variously as *ctung, ctoong,* or *ctoonk.* Some of these notes were given singly, and some as a series of two, with an appreciable interval between them. On the morning of May 18, 1930, at Suwannee Lake, a rolling quality was noted in some of the calls: *crrunk, crrunk;* or *ctunk, crrunk, c'rrunk, c'rrunk.*

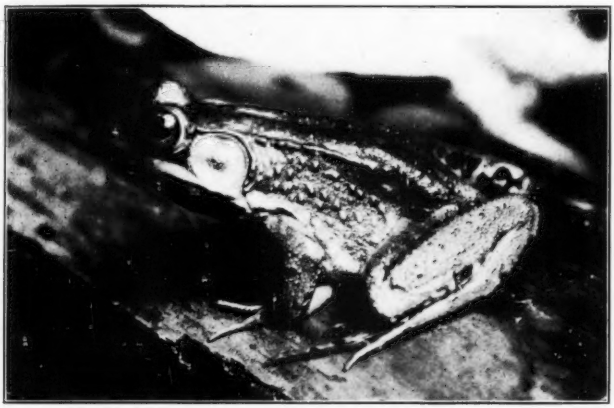

Fig. 13. *Rana clamitans,* adult, on an old railroad tie in a cypress bay. Floyd's Island, Okefinokee Swamp, Ga. June 15, 1929 (12 p.m.).

Just after midnight of July 25-26, 1922, following a heavy thunderstorm in the late afternoon, a number of Green Frogs were calling in a bay bordering Chesser's Island. All seemed to be giving merely a single note thus late in the season, at intervals of perhaps a minute or so.

Of the various tailless amphibians of the Okefinokee region, this species has very nearly, if not quite, the most northerly distribution. It also frequents by preference some of the coolest and shadiest spots in the region—springs, cypress ponds, cypress bays, river swamps, and borders or interiors of prairie "heads." It appears to avoid for the most part the warm shallows of the open prairies. Perhaps it is not so thoroughly adapted to this warm climate as are most of the other local species.

Florida.—Along the St. Mary's River in Nassau County I heard one on August 12, 1921, several miles south of St. George, Ga.; another on August 15 several miles south of Trader's Hill, Ga.; and several on August 16 near Boulogne.

Tennessee.—One was heard on June 15 at a lake near Parksville, Polk County, and another on June 18, 1934, at Gatlinburg, Sevier County.

Rana grylio Stejneger. SOUTHERN BULLFROG

Georgia.—All through the summer the choruses of this frog constitute one of the most regular and characteristic of the nocturnal sounds of the Okefinokee prairies and cypress bays. It is also common in the cypress ponds of the swamp islands and of the mainland bordering the swamp. Sphagnous bogs form an additional habitat of the species, for in June, 1929, I heard it commonly in such a bog surrounding Bugaboo Island. On the other hand, it appears to largely avoid the creek and river swamps. At any rate, I did not record it in the entire length of the St. Mary's River, from Moniac to its mouth, while voyaging downstream in August, 1921. It seems to be quite unknown at Suwannee Lake and along the adjoining parts of Suwannee Creek in Ware County. I have also failed to note it at various points on the Satilla, Altamaha, and Ohoopee Rivers. Thus its habitat distribution seems to be more or less complementary to that of *Rana heckscheri.*

During the severe drought of April, 1932, when the Okefinokee prairies had practically dried up and only a little water remained in the lakes and gator-holes, no Southern Bullfrogs were in evidence and it seemed as if they must have largely perished. In 1933, however, they were heard in fairly normal numbers on Chesser's and Grand Prairies on various occasions from April 11 to 22.

Now and then, when startled, one of these prairie frogs will make a series of splashing leaps along the surface of the water before submerging, and sometimes it chirps as it goes.

On August 13, 1922, one was heard 5 miles north of St. Mary's in Camden County. During the evening of April 6, 1933, one was heard at a pool some distance back from the Savannah River, below the city of Savannah. This is apparently the northeasternmost published record of the species.

Rana heckscheri Wright. ALLIGATOR FROG

Georgia.—The habits of this species, as observed at Suwannee Lake, Ware County, from 1929 to 1931, have already been discussed (1932). During the extreme drought of April, 1932, when this lake had been reduced to a stagnant, *Lemna*-covered pool 4 or 5 feet below its normal level, no Alligator Frogs could be found about it, and I feared they were practically exterminated locally. But when abundant rains came during the following month, Mr. Hamp Mizell reported about as many of this species as usual. Evidently the breeding season of 1932 (say May and June) was quite successful, for by November the residents began to notice here a considerable number of the tadpoles, apparently for the first time in their experience. An increase in the size of the tadpoles during the next five months was remarked upon. The success of the breeding season may have been due in part to reduction in the number of their enemies (snakes, fishes, etc.) as a result of the drought. This is perhaps an illustration of the rapidity with which nature restores its own equilibrium after temporary setbacks, especially those due to other than human agencies.

On April 26, 1933, I found the strikingly marked tadpoles common among the water-weeds in the shallows at the boat landing, and secured two

of them in the two-legged stage (121 and 126 mm.). The network of lateral lines is evident in the photograph of one of them (Fig. 14). On the following two nights several of the frogs, about half or two-thirds grown, were noticed here. But no full-grown adults were definitely identified, and no bellowing was reported during the spring up to that ime.

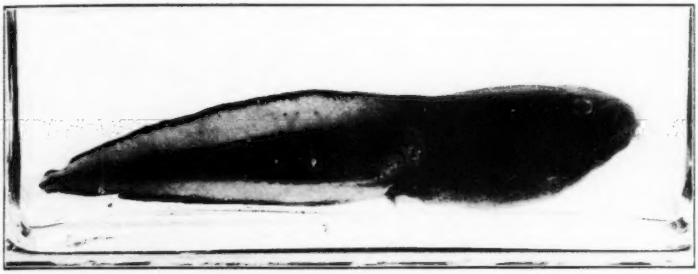

Fig. 14. *Rana heckscheri*, two-legged tadpole, about 126 mm. (F. H. No. 182.) Suwannee Lake, Ware County, Ga. April 26, 1933.

On April 9, 1933, a group of large tadpoles, with a dark lateral stripe in the tail, was observed in a wide pool formed by excavations for a bridge approach on the east side of the Satilla River near Atkinson, Brantley County. There can be scarcely a doubt that they belonged to the present species, especially since a second record was secured farther upstream on April 30. The latter locality was along U. S. Route 1, on the south side of the Satilla a few miles northwest of Waycross, in Ware County. Here, as farther down the river, and also at Callahan, Fla. (where I observed the tadpoles in 1922), a large pool had resulted from excavations for a road embankment. It was perhaps 25 by 75 yards in extent, and was connected with the river by a narrow outlet. In walking along the border of the pool, I began to notice some peculiar-looking frogs sitting on the bank. They were so unlike any frog I was familiar with, that I almost suspected a new species. They were mostly very shy, leaping into the water at my approach and swimming off beneath the surface. But where the water was very shallow, some of them skittered away from the shore in a remarkable manner. Their hind feet probably touched the bottom at each splashing step or leap through the shallows. Meanwhile they apparently maintained a semi-upright position, suggesting to me illustrations of the bipedal gait of the Australian Frilled Lizard *(Chlamydosaurus kingii)*. A similar method of progression on the part of recently metamorphosed individuals of *Rana catesbeiana* in California has been recorded by Burt (1933, p. 353).

Presently the sight of some tadpoles of *Rana heckscheri* in the pool gave a clue to the identity of the frogs of such remarkable appearance and behavior, and the capture of several transforming individuals with a remnant of a striped tail settled the question. In short, the puzzling individuals on the bank were just completing transformation, and as yet bore comparatively little

resemblance to full-grown adults. Two individuals approaching transformation, and captured in the water, measured 52.5 and 51.5 mm. from snout to vent, and possessed tails of 9 and 33 mm., respectively. Apparently this stage was more numerous than the transformed stage that had left the water.

A representative of the latter stage (Figs. 15, 16) still retained the merest stub of a tail, and showed in the dorso-lateral region some traces of the prominent lateral-line system of the tadpole. It also retained in some measure the tadpole's softness of body. It is 52 mm. from snout to vent. In life it was greenish olive above, and finely speckled; the iris was golden bronze. In spirits the throat and the ventral side of the limbs have conspicuous dark reticulations on a light ground; the venter is slightly reticulated around the periphery, but almost clear in the middle. This stage in the life history does

Fig. 15. *Rana heckscheri*, just transformed, 52 mm., dorsal aspect. (F. H. No. 193.) Satilla River, Ware County, Ga. April 30, 1933.

not appear to have been previously figured. No older individuals were encountered along the Satilla River.

Owing to the extreme drought conditions that prevailed locally during the early part of 1932, up to May, it appears likely that the transforming individuals of the Satilla, as well as the two-legged tadpoles of Suwannee Lake, were derived from eggs laid not earlier than May, 1932. The more advanced stage encountered along the Satilla might be accounted for by an acceleration

of growth in this shallow, unshaded, almost stagnant pool. Deeper and cooler water in Suwannee Lake, with its slight current and well-shaded shores, would probably bring about a certain retardation of development, as compared with conditions along the Satilla.

During the night of April 30, 1933, while my attention was occupied chiefly with *Hyla avivoca* at a bayou on the Ohoopee River several miles southwest of Reidsville, Tattnall County, I also heard some deep, sonorous rolls similar in general to those I had heard from the Alligator Frog at Suwannee Lake in previous years. Each of the calls had a duration of approxi-

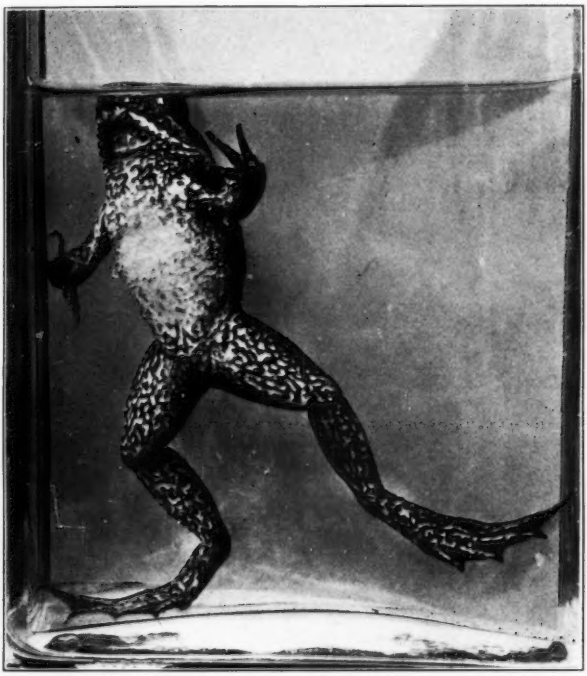

Fig. 16. *Rana heckscheri*, just transformed, 52 mm., ventral aspect. (F. H. No. 193.) Satilla River, Ware County, Ga. April 30, 1933.

mately 1 second. The average of 17 intervals elapsing between the beginnings of consecutive calls was 2.3 seconds, the extremes being 2 and 3 sconds; thus the silent intervals between the end of one call and the beginning of the next averaged approximately 1.3 seconds. The only other local species, with which the one calling here might have been confused, is the Gopher Frog. But the bayou habitat is far more appropriate for the Alligator Frog, and its presence

here is fairly to be expected, in view of my discovery of the species farther up the Ohoopee in Emanuel County in 1932 (1933, p. 230).

In voyaging down the St. Mary's River in 1921, I heard what was almost unquestionably the voice of this species at about nine points in Charlton County, Ga., and Baker and Nassau Counties, Fla. More or less sporadic calls were recorded on every day but one from August 9 to 17, from a point north of Macclenny, Fla., to one southeast of Folkston, Ga. At that time the present species had not been described, and I attributed the notes to the Gopher Frog. Although the ordinary guttural roll of the Alligator Frog might be mistaken for the voice of the Gopher Frog, its other note—a snarling yelp or grunt—was heard on several occasions, and is apparently diagnostic. Several tadpoles were found in the river at Camp Pinckney, Charlton County, and one at Kings Ferry, Nassau County; both of these points are reached by tide water.

Fig. 17. *Rana sphenocephala*, adult, in edge of Chesser's Prairie. Okefinokee Swamp, Ga. July 23, 1931.

Rana sphenocephala Cope. SOUTHERN LEOPARD FROG

North Carolina.—On April 2, 1933, one was collected at a woodland pool among old sand dunes near Kitty Hawk, Currituck County. During the evening of April 3 (est. temp. 60°) several were heard at Edenton, Chowan County. Here the guttural notes sounded somewhat as follows: *wrrrk-rk-rk-rk, wrrrk-rk-rk-rk; wauk, wauk, wauk,* etc.

South Carolina.—One was seen a few miles from McBee, Chesterfield County, on June 9, 1922.

Georgia.—Certain observations on the time of day or night when vigorous choruses are heard, seem to indicate that the summer temperatures of the Okefinokee region are frequently too high to furnish optimum conditions for the breeding of this species. At a time of abundant summer rainfall nearly all the other local species of frogs will indulge in great vocal activity as soon as darkness comes, if not before. I have noted, however, on a considerable num-

ber of occasions from May 17 to August 20, that the strongest choruses of *Rana sphenocephala* come between midnight and dawn during this period. Often it calls less vigorously or not at all during the first half of these chorus nights. With many of the other species, on the contrary, there is apt to be a marked subsidence of vocal activity after midnight—perhaps from exhaustion, perhaps on account of falling temperature, and perhaps for both reasons.

May it not be precisely this lowering of temperature in the latter part of the night that stimulates the calling of *sphenocephala?* For example, a great chorus was heard before daybreak on both August 20 and 22, 1922, at a cypress pond on Chesser's Isalnd. The temperature was 72° at 5:50 a. m. on the 20th, and 66° at 6:30 a. m. on the 22nd. On August 19 there had been a hard shower in the early afternoon, but the temperature was up to 74° at 9:10 p. m., and *sphenocephala* was not heard among at least four other species calling during the evening. On August 21 no rain was recorded, the temperature was 71° at 10:25 p. m., and no *sphenocephala* was heard during the evening.

It may be recalled that the affinities of this species are boreal rather than austral, for its closest relative, *Rana pipiens,* is one of the most northerly ranging of American frogs. Furthermore, during the winter and spring some of its most pronounced vocal activity may be noted in the daytime. Thus on December 26, 1916, I heard a loud chorus on Billy's Island during the late afternoon and evening. On April 24, 1921, in the same area, the frogs were calling so actively and so intently during the latter part of a sunshiny morning that I was able to approach close enough for a photograph of a croaking male. (At night, however, I have found it the shyest and the most difficult to approach of the various Okefinokee frogs.) My records indicate that the maximum temperature at which this species croaks is about 72°-75°; and this temperature is generally exceeded here in daytime during the summer months. (The mean temperature at Waycross during May is 74.6°; June, 80.1°; July, 81.9°; August, 81.4°.)

In the Okefinokee region the croaking consists of two kinds of notes, similar in tone but slightly different in form. It may begin with a guttural series of grunts: *wauk, wauk, wauk.* Then as the frog warms to its performance, the note becomes a loud, rattling *w-r-r-r-k, w-r-r-r-k, w-r-r-r-k.* A chorus of such notes, at a distance, suggests the rumbling of a farm wagon on a rough road. When the frog is calling in full voice, its paired lateral sacs become more distended than when it calls with less vigor.

On July 31, 1922, two large individuals in a small pool near the St. Mary's River at Thompson's Landing, Charlton County, forsook the water at my approach, leaping high up the bank and retreating into a saw-palmetto bed. On April 14, 1933, I noted similar behavior on the part of numbers of these frogs at a couple of small pools on Chesser's Island; they left the water and took to the grass and brush with high leaps, covering as much as 3 or 4 feet at a leap.

On April 22, 1932, during a period of severe drought, I found a sluggish individual beneath a slab on dark muck at the "Lower Lake," near Suwannee Lake, Ware County. It was of such a dark chocolate color that the dorsal

spots were distinguished with difficulty; there was no white spot on the tympanum, and no green on the body.

During the evening of April 6, 1933, several were heard on the outskirts of Savannah. During the evening of April 30, 1933, one was heard along the Ohoopee River several miles southwest of Reidsville, Tattnall County.

Rana virgatipes Cope. CARPENTER FROG

North Carolina.—On April 4, 1933, I collected one (39 mm.) in a sphagnous swamp in Beaufort County 7 miles north of Vanceboro.

Georgia.—In June, 1929, I heard this species in small numbers, by day as well as by night, at the following places in Okefinokee Swamp: near Suwannee Canal (2nd and 20th); sphagnous bog surrounding Bugaboo Island (6th, 11th, and 12th); cut-over cypress bay bordering Floyd's Island (15th, 16th, and 19th); Floyd's Island Prairie (18th). On this prairie the number of notes (*c'tuck-c'tuck-c'tuck*, etc.—suggesting the sound of distant hammering) in several consecutive calls was recorded as follows: 5, 5, 6, 6, 4, 5. Some of the calls were prefaced with a rolling grunting note. The temperature at the time of diurnal calls varied from about 60° (June 12) to 87° (June 2); at the time of nocturnal calls, from 66° (June 6) to about 77° (June 19).

On May 30, 1930, the species was heard about 11:20 a. m. on Chesser's Prairie. On July 20, 1931, at a small pond in a sphagnous bog bordering Chesser's Island, I secured two specimens (51 and 39 mm.) by scooping up floating clumps of *Eriocaulon* in a dipnet, the frogs not being seen until found in the bottom of the net. On April 13, 1932, when Chesser's Prairie had practically dried up, one (41 mm.) was found there in a little water at the bottom of a hole that had perhaps been formed by a hog's rooting.

In 1933 mostly single individuals were heard on Chesser's Prairie and in the adjoining cypress bay at various daylight hours on April 11, 17, 18, 19, 21, and 22. One was heard during the evening of April 16 (temp. 60°), and a fair number during the following evening (temp. 60°). A moderate chorus was heard during the nights of April 18-19 and 19-20 (temp. in the vicinity of 60° during both nights). The notes are easily audible at a quarter of a mile or more.

The vocal sacs, when inflated, are light brownish in color. The notes are uttered rapidly, at a rate of about three per second. On July 21, 1922, in a bay near Chesser's Island, I heard probably six or eight croaking males within a radius of 50 feet; some were probably within 10 or 12 feet of each other. A typical croaking position seemed to be on some moss, with the head, upper back, and vocal sacs above the surface of the water. The water was about 4 to 6 inches in depth. Here, as elsewhere, sphagnum seemed to be a more or less essential element in the habitat. When much disturbed, one of the frogs would take refuge on the bottom, after swimming two or three feet from its original position.

Gastrophryne carolinensis (Holbrook). CAROLINA NARROW-MOUTHED TOAD

Tennessee.—After hard showers and while it was still raining during the evening of June 17, 1934 (temp. about 76°), I located a group of perhaps

ten calling individuals in a marshy roadside puddle in the eastern outskirts of Etowah, McMinn County (alt. 800 ft.). Two of them were seen squatting in the edge of the water, with approximately the upper half of the body above the surface, and one of them (26.5 mm.) was collected. Others were evidently out from the shore among the vegetation of the puddle.

This locality in the Appalachian Valley (Fenneman, 1916, p. 50) is perhaps the easternmost and highest one in Tennessee from which the species has been recorded; it is evidently in the Upper Austral Zone (as indicated by the presence of the Song Sparrow and the Purple Grackle). The nearest other station recorded is apparently "near Chattanooga" (Rhoads, 1895, p. 396).

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Swarthmore, Pa.

FURTHER RECORDS OF THE ECOLOGY AND DISTRIBUTION OF AMPHIBIANS AND REPTILES IN THE MIDDLE WEST

CHARLES E. BURT

Introduction and Acknowledgments

The present contribution is the result of frequent field expeditions in the area drained by the Mississippi River and its tributaries, with special reference to work carried on during the collecting season of the year 1934. Through the courtesy of Dr. Alexander Wetmore, Director of the United States National Museum, a grant was extended from the funds of the Smithsonian Institution to support the project in the Lower Mississippi Valley during the summer of 1934 and especially valuable records have been secured in Arkansas and Louisiana. Most of the specimens reported here have been deposited in the collection of the United States National Museum.

The area covered by this report includes sections of Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Louisiana, Michigan, Minnesota, Missouri, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wisconsin; but the major portion deals with the herpetology of Arkansas, Kansas, Louisiana, and Oklahoma.

Students of Southwestern College, friends and correspondents who have collected specimens discussed herein, are listed alphabetically as follows: Harry Albrecht, Phil Antrim, Elmer P. Cheatum, Bertha L. Danheim, David Garrett, Albert A. Heinze, Dorothy Boyer Heinze, Luther Hoyle, Frances McGill, Malcolm V. Parker, Cornelius R. Rogers, Ottys Sanders, Wallace Schaefer, and Hobart M. Smith. Mr. Hoyle and Mr. Rogers served as field assistants during the expeditional work in Arkansas and Louisiana in June and July, 1934, where they rendered excellent service.

Before presenting the list of species, I wish to take this opportunity to express my appreciation to Mr. Guy Amsler, Secretary of the Arkansas Game and Fish Commission; to Mr. Robert S. Maestri, State Fish and Game Commissioner of Louisiana; and to Mr. W. G. Strong, State Fish and Game Warden of Kansas, for permits to seine in the waters under their respective jurisdictions while collecting the amphibians and reptiles reported here. The Arkansas and Louisiana permits were obtained through Dr. Alexander Wetmore of the Smithsonian Institution.

List of Species

SALAMANDERS

Ambystoma opacum (Gravenhorst)

Marbled salamanders were found in moist situations either in the woods under rotted logs or at old logging sites under pieces of lumber around saw dust piles. An individual taken in Montgomery County, Arkansas, on June 4, had obscure white spots and a body length of 32 mm., while two examples found in a wooded swamp near Waverly, Louisiana, on June 22 had body lengths of 31 and 40 mm., respectively.

Arkansas—CRAIGHEAD: 6 mi. N. Jonesboro (June 11, 1934). GREENE: 4 mi. S. E. Paragould (Parker, May 11, 1934). INDEPENDENCE: Olyphant (June 9, 1934). MONTGOMERY: Oden (June 4, 1934).

Louisiana—MADISON: 1 mi. E. Waverly (June 25, 1934). SABINE: 4 mi. S. W. Many (June 16, 1934).

Ambystoma tigrinum (Green)

Miss Danheim collected the tiger salamander at La Salle, La Salle County, Illinois, on June 6, 1933; and Mr. Rogers took an electrocuted individual at Lake City, Barber County, Kansas, on September 1, 1934. The unfortunate salamander involved in this case had come into contact with a wire fence during a rain. Water had caused a short circuit to develop in a metal covered building to which the fence was attached. The salamander quivered for a long time after its experience, but it never regained consciousness.

Plethodon glutinosus (Green)

Slimy salamanders were discovered in rotting logs at the border of a sylvan streamlet near Crystal Springs, Garland County, Arkansas, on June 4, 1934. They were also taken in a similar situation 9 miles east of Mt. Ida, Montgomery County, Arkansas, on the same day, where a young individual that was 28 mm. in length showed only small, non-fungiform spots on the sides.

Plethodon ouachitae Dunn and Heinze

A small salamander was secured under a log near a spring at the base of the mountains 6 miles northwest of the settlement of Rich Mountain (and just east of the state line), Polk County, Arkansas, on June 3, 1934. The markings on the sides were not well developed, so I doubtfully refer the specimen to this very close relative of *glutinosus*.

Eurycea bislineata cirrigera (Green)

A larval long-tailed salamander was obtained in a shallow gravel-bottomed woodland streamlet below the opening of a mountain spring 2 miles south of Forum, Madison County, Arkansas, on June 22, 1934. The middorsal area showed two rows of black dots, but the bars on the tail were relatively indistinct. The body length was 20 mm.

Eurycea quadridigitata quadridigitata (Holbrook)

Four-toed salamanders of this subspecies were collected under logs and

boards in moist wooded plots near old saw mill sites in Louisiana at Doyle Springs 11 miles northwest of Jena, La Salle Parish (June 15, 1934); and 4 miles southwest of Many, Sabine Parish (June 16, 1934).

Desmognathus fuscus auriculatus (Holbrook)

A dusky salamander from under a log near a streamlet 2 miles east of Minden, Webster County, in northern Louisiana (June 24, 1934), has obscure white spots on the sides and the under surfaces are darkly mottled, so it is referred to *auriculatus* rather than to *brimleyorum*.

Desmognathus fuscus brimleyorum Stejneger

Like its relatives *fuscus* and *auriculatus* in the Southeast, this subspecies occurs under rocks, logs, and stones in water soaked areas near ponds and streamlets, especially in cooler, more mountainous districts. Specimens from Montgomery County, Arkansas, have dark under surfaces and distinct lateral spots, comparing closely with many examples of *auriculatus*, but not being especially typical of that form. Atavism between *auriculatus* and *brimleyorum* probably occurs in this region (and at other points as well).

Arkansas—CARROLL: 2 mi. N. W. Eureka Springs (June 22, 1934). GARLAND: Crystal Springs (June 4, 1934). HOT SPRING: 2 mi. N. Estes (June 4, 1934). MONTGOMERY: Oden (June 4, 1934). PERRY: 8 mi. S. E. Ola (June 8, 1934). POLK: Just E. of state line 6 mi. N. W. Rich Mountain settlement (June 3, 1934).

Oklahoma—LEFLORE: Just W. of State line 6 mi. E. Page (June 3, 1934).

TOADS

Scaphiopus bombifrons Cope

This spadefoot toad was collected near a pond 1 mile west of Broken Arrow, Tulsa County, Oklahoma, on May 6, 1934.

Scaphiopus hammondii Baird

Mr. Garrett found plains spadefoot toads in Denver, Denver County, Colorado, on July 15, 1932; and Mr. Hoyle took the species 18 miles southwest of Las Cruces, Dona Ana County, New Mexico, on June 22, 1933, at the border of a large permanent pond of water. Hoyle's specimens were dead when found and since there had been recent rains in this normally arid environment, where yucca and sage brush were the prevailing vegetation, he concluded that they had probably been "drowned by the flood of incoming water and then washed down to the pond."

Bufo americanus americanus Holbrook

A large watersnake *(Natrix erythogaster transversa)* that was captured in Polk County, Arkansas, soon regurgitated a living adult of this subspecies, which started to hop away after gaining its freedom. Amplexus was observed in these toads on April 2, in Lincoln County, Oklahoma.

Arkansas—GARLAND: 2 mi. E. Royal (June 4, 1934). MONTGOMERY: 4 mi. N.E. Waters (June 3, 1934). NEWTON: 1 mi. S. Willcockson (June 6, 1934). POINSETT: Marked Tree (June 11, 1934). POLK: 3 mi. E. Cherryhill (June 3, 1934). PULASKI: 9 mi. N. Little Rock (June 5, 1934).

Oklahoma—LeFlore: Just N. Page (June 3, 1934). Lincoln: 1 mi. S. Agra (April 2, 1934). Muskogee: 5 mi. S. Haskell (May 7, 1934). Pittsburg: 2 mi. S. E. McAlester (June 3, 1934). Tulsa: 1 mi. W. Broken Arrow (May 6, 1934).

Bufo cognatus Say

These ornate nocturnal creatures are most often obtained from the road after a rain.

Oklahoma—Grant: 2 mi. E. Medford (Hoyle, June 9, 1933); 10 mi. E. Medford (Hoyle, June 9, 1933).

South Dakota.—McCook: 2 mi. N. Dalton (July 17, 1934).

Bufo punctatus Baird and Girard

This squat little toad was found under a large flat rock in a prairie ledge in a surprisingly dry situation 8 miles northwest of Togo, Major County, Oklahoma, on May 29, 1934.

Bufo terrestris (Bonnaterre)

This southern toad has very high cranial knobs in the more southern part of its range but lower cranial knobs are borne farther north. These northern specimens present a morphological intergradation between *americanus* and *terrestris*, which are very closely allied and perhaps subspecies derived from a common stock. It is very difficult to distinguish young *terrestris* with poorly developed, indistinct cranial ridges from like representatives of *woodhousii* when the two forms occupy a common range. The same difficulty becomes apparent in identifying juvenile specimens of *americanus* and *woodhousii* in more northern areas.

Arkansas—Dallas: Fordyce (June 4, 1934). Hot Spring: 2 mi. N. Estes (June 4, 1934). Newton: 1 mi. N. Ponca (June 22, 1934).

Louisiana—Catahoula: 2 mi. S.W. Utility (June 15, 1934). Concordia: 4 mi. E. Ferriday (June 2, 1934); 5 mi. S.W. Ferriday (June 15, 1934); 1 mi. W. Vidalia (June 2, 1934). Lincoln: 1 mi. W. Choudront (June 22, 1934).

Bufo valliceps Wiegmann

Two young specimens of this form from a wooded tract 3 miles northwest of Gonzalez, Ascension Parish, Louisiana (July 3, 1934), have a body length of 25 mm. When compared with *woodhousii* of the same size these small *valliceps* have a much more roughly granular(and even spinose) skin, especially on the back. The cranial crests of *valliceps* are very sharp and distinct in the adult and they appear at an earlier age in the young.

An adult *valliceps* was secured near the Louisiana State University Biological Station on Grand Isle, Jefferson Parish, Louisiana, on July 4, 1934.

Bufo woodhousii Girard

Bufo woodhousii Girard, Proc. Acad. Nat. Sci. Philadelphia **7**:86, 1854 (type locality, San Francisco Mountain, Coconino County, Arizona).

Bufo fowleri Hinckley, Proc. Boston Soc. Nat. Hist. **21**:310, 1882 (type locality, Milton, Massachusetts).

The detailed comparison of large numbers of the common "*fowleri*" of the Southeast with extensive series of "*woodhousii*" from the Middle West reveals no significant diagnostic differences, so I consider the two populations

as one species under the earliest name *woodhousii*. Statistical data pertaining to this question may be expected to appear elsewhere.

One toe of an adult *woodhousii* was seen sticking out of the mouth of a large bullfrog *(Rana catesbeiana)* in Lincoln County, Oklahoma, on the evening of April 2. On May 6 another adult toad was found in Tulsa County, Oklahoma, in the distended mouth of a giant watersnake *(Natrix rhombifera)*.

Young *woodhousii* toads secured in Arkansas on June 8 measured from 10 to 16 mm. in body length, while those taken in the same state on June 24 measured from 14 to 19 mm.

Arkansas—CLARK: 5 mi. S. Arkadelphia (June 24, 1934). CRAWFORD: 8 mi. N.W. Natural Dam (June 8, 1934). DALLAS: 1 mi. N. Fordyce (June 4, 1934). GREENE: 8 mi. E. Paragould (June 11, 1934). LAWRENCE: 3 mi. N.W. Black Rock (June 9, 1934). LOGAN: Booneville (June 8, 1934). MADISON: 2 mi. S. Forum (June 22, 1934); Kingston (June 22, 1934). NEVADA: 5 mi. S. Prescott (June 24, 1934). RANDOLPH: 1 mi. S.W. Biggers (June 10, 1934). WASHINGTON: 4 mi. S. Dutch Mills (June 7, 1934). YELL: Just W. Havana (June 8, 1934); 5 mi. E. Plainview (June 8, 1934).

Louisiana—ASCENSION: 3 mi. N.W. Gonzales (July 3, 1934). BIENVILLE: 1 mi. E. Arcadia (June 24, 1934). CONCORDIA: 2 mi. S.W. Ferriday (June 15, 1934). LASALLE: Doyle Springs 11 mi. N. W. Jena (June 16, 1934). SABINE: 3 mi. E. Pendleton Ferry (June 16, 1934). SAINT CHARLES: 2 mi. N.E. Ama (July 3, 1934). WINN: Sunnett Creek 7 mi. S.W. Winnfield (June 16, 1934).

Missouri—VERNON: Sheldon (June 22, 1934).

Nebraska—BOYD: Lynch (August 2, 1932).

Oklahoma.—ALFALFA: 3 mi. E. Vining (April 21, 1934). BECKHAM: 4 mi. W. Sayre (May 28, 1934). LINCOLN: 1 mi. S. Agra (April 2, 1934). TULSA: 2 mi. S.E. Alsuma (May 6, 1934); 1 mi. W. Broken Arrow (May 6, 1934).

FROGS

Acris gryllus (Le Conte)

Cricket frogs were singing at night above a sluggish streamlet at King ston, Arkansas, on June 22, where several pairs were observed in amplexus and egg laying was in progress.

Arkansas—BENTON: 1 mi. W. Garfield (June 7, 1934); 3 mi. N. E. Gateway (June 22, 1934); 5 mi. E. Pea Ridge (June 7, 1934). CLARK: 5 mi. S. Arkadelphia (June 24, 1934). DALLAS: 1 mi. S. Princeton (June 4, 1934). GARLAND: 2 mi. E. Royal (June 4, 1934). HOT SPRING: 2 mi. N. E. Bismark (June 23, 1934). LAWRENCE: 3 mi. N.W. Black Rock (June 9, 1934). LOGAN: Just W. Booneville (June 8, 1934). MADISON: 2 mi. S. Forum (June 22, 1934); Kingston (June 22, 1934). MONTGOMERY: Just E. Oden (June 4, 1934). NEVADA: 2 mi. S. Prescott (June 24, 1934). NEWTON: 2 mi. S. Jasper (June 6, 1934); 1 mi. N. Ponca (June 22, 1934); 5 mi. S. Ponca (June 23,1934); 2 mi. S. Willcockson (June 6, 1934). POINSETT: Marked Tree (June 11, 1934). POLK: Trumann (June 11, 1934); 2 mi. E. Cherryhill (June 3, 1934). POPE: 15 mi. N. Dover (June 6, 1934). PULASKI: 3 mi. N.E. Jacksonville (June 8, 1934); North Little Rock (June 6, 1934). RANDOLPH: Pocahontas (June 9, 1934). WASHINGTON: Cincinnati (June 7, 1934); 4 mi. S. Summers (June 7, 1934). WHITE: 2 mi. S.E. Judsonia (June 9, 1934).

Illinois—KANKAKEE: Sherburnville (June 7, 1933). WILL: 3 mi. N. Beecher (June 7, 1933).

Indiana—LAKE: 3 mi. W. Belshaw (June 7, 1933).

Iowa—HANCOCK: 1 mi. S.W. Klemme (July 23, 1934). WRIGHT: Belmond (July 23, 1934).

Louisiana—CALCASIEU: 2 mi. E. Edgerly (July 6, 1934); 10 mi. E. Lake Charles (July 5, 1934). CONCORDIA: 4 mi. E. Ferriday (July 2, 1934); 7 mi. S.W. Ferriday (June 15, 1934). RICHLAND: 1 mi. W. Girard (June 25, 1934). SABINE: 3 mi. E. Pendleton Ferry (June 16, 1934). SAINT CHARLES: 3 mi. N.E. Ama (July 3, 1934). WEBSTER: 1 mi. S. Couchwood (June 24, 1934). WEST FELICIANA: 1 mi. N. Laurel Hill (July 2, 1934). WINN: Sunnett Creek 7 mi. S.W. Winnfield (June 16, 1934).

Missouri—BUCHANAN: 4 mi. N. Easton (June 3, 1933). LINN: 4 mi. W. Laclede (June 3, 1933). PEMISCOT: 4 mi. S.W. Bragg City (June 10, 1934). VERNON: Sheldon (June 22, 1934).

OKLAHOMA—ALFALFA: 2 mi. W. Goltry (May 29, 1934); 3 mi. E. Vining (April 21, 1934). CUSTER: 5 mi. N.E. Butler (May 28, 1934); Hammon (May 28, 1934). GARFIELD: 1 mi. S.E. Hillsdale (May 29, 1934). GREER: 4 mi. S.E. Magnum (Hoyle, June 10, 1933). HUGHES: 3 mi. N. Calvin (June 2, 1934); 2 mi. W. Holdenville (June 2, 1934). LATIMER: Fourche-Moline Creek 1 mi. E. Wilburton (June 3, 1934). LEFLORE: Just W. state line 6 mi. E. Page (June 3, 1934). LINCOLN: 1 mi. S. Agra (April 2, 1934). MUSKOGEE: 3 mi. N. Boynton (May 7, 1934); 5 mi. S. Haskell (May 7, 1934). NOWATA: 2 mi. N. Delaware (April 1, 1934).OKLAHOMA: 2 mi. S. Harrah (June 2, 1934). OKMULGEE: 2 mi. S. Morris (May 7, 1934). OSAGE: 10 mi. S.W. Bartlesville (April 3, 1933). PAYNE: 1 mi. S.E. Perkins (May 7, 1934). PITTSBURG: 1 mi. N.W. Haileyville (June 3, 1934); 2 mi. W. McAlester (June 3, 1934); 3 mi. N.E. Stuart (June 2, 1934).

Pseudacris nigrita clarkii (Baird)

These little frogs are often found under flat rocks in the prairies of north central Oklahoma during the spring. Records were secured 4 miles west of Lyman (Apr. 11, 1934) and 6 miles northeast of Newkirk (Apr. 29, 1933), in Kay County.

Pseudacris nigrita triseriata (Wied)

This subspecies occurs in both wooded and prairie districts about various bodies of water. Individuals often seek concealment in damp situations beneath rotting logs during the day.

Arkansas—DALLAS: 1 mi. S. Princeton (June 4, 1934). GREENE: 5 mi. S.W. Paragould (Parker, March 21, 1934). MONTGOMERY: 4 mi. N.E. Waters (June 3, 1934). PULASKI: 2 mi. S.E. Armstead (June 6, 1934).

Iowa—HANCOCK: 1 mi. S.W. Klemme (July 23, 1934).

Louisiana—CONCORDIA: 2 mi. S.W. Ferriday (June 15, 1934).

Nebraska—JEFFERSON: 5 mi. N.E. Thompson (May 14, 1933).

Oklahoma—LINCOLN: 1 mi. S. Agra (April 2, 1934). NOWATA: 2 mi. N. Delaware (April 1, 1934). ROGERS: 3 mi. N. Talala (April 1, 1934).

South Dakota—MINNEHAHA: 11 mi. W. Sioux Falls (July 17, 1934).

Pseudacris streckeri Wright and Wright

This species may be heard in the spring as it utters its peculiar whistling song about the margins of streams, pools, and ponds. Specimens were collected in Oklahoma 1 mile south of Agra, Lincoln County, (Apr. 2, 1934); and 1 mile west of Broken Arrow, Tulsa County (May 6, 1934).

Hyla cinerea cinerea (Schneider)

This beautiful tree frog lives in marshy areas where its loud call is frequently heard throughout the summer, especially at rainy periods.

Arkansas—CRITTENDEN: 2 mi. S. Turrell (June 12, 1934). LENOKE: 3 mi. S.W. Cabot (June 8, 1934). POINSETT: Marked Tree (June 11, 1934). PULASKI: 3 mi. N.E. Jacksonville (June 8, 1934).

Louisiana—ACADIA: Mermenton (Sanders, May 1932). CALCASIEU: 10 mi. E.

Lake Charles (July 5, 1934). CATAHOULA: 2 mi. S.W. Utility (June 15, 1934). CONCORDIA: 7 mi. S.W. Ferriday (June 15, 1934). LAFOURCHE: Raceland (July 4, 1934). SAINT CHARLES: 3 mi. N.E. Ama (July 3, 1934). SAINT MARY: 1 mi. W. Franklin (July 5, 1934).

Hyla crucifera Wied

Mr. Parker took this frog 2 miles northwest of Monette, Craighead County, Arkansas, on March 17, 1934, where series of small black dots appear on the chest to remind one of the condition found in *Pseudacris nigrita brimleyi* of the eastern coastal plain.

Hyla versicolor versicolor Le Conte

The common tree frog was found in amplexus near Ponca, Arkansas, on June 22.

Arkansas—CLEVELAND: 14 mi. W. Rison (June 5, 1934). DALLAS: 1 mi. N. Faringdale (June 5, 1934); 1 mi. N. Fordyce (June 4, 1934); 1 mi. S. Princeton (June 4, 1934). GRANT: Just N. Sheridan (June 5, 1934). HOT SPRING: 2 mi. N.E. Bismarck (June 23, 1934); 2 mi. N. Estes (June 4, 1934). LENOKE: 3 mi. S.W. Cabot (June 8, 1934). MADISON: Kingston (June 22, 1934). MONTGOMERY: 4 mi. N.E. Waters June 3, 1934). NEWTON: 2 mi. S. Jasper (June 6, 1934); 1 mi. N. Ponca (June 22, 1934); 2 mi. S. Willcockson (June 6, 1934). POLK: 2 mi. E. Cherryhill (June 3, 1934). 6 mi. N.W. Rich Mountain settlement, just E. state line (June 3, 1934). PULASKI: 3 mi. N.E. Jacksonville (June 8, 1934); North Little Rock (June 6, 1934). RANDOLPH: Pocahontas (June 9, 1934). WASHINGTON: 4 mi. S. Summers (June 7, 1934).

Louisiana—SABINE: 4 mi. S.W. Many (June 16, 1934).

Missouri—BUCHANAN: 4 mi. N. Easton (June 3, 1933). PEMISCOT: 4 mi. S.W. Bragg City (June 10, 1934).

Oklahoma—LEFLORE: Just N. Page (June 3, 1934). TULSA: 1 mi. W. Broken Arrow (May 6, 1934).

Rana areolata Baird and Girard

Along a marshy streamlet on a state game reserve 3 miles north of Talala, Rogers County, Oklahoma, one of these rare frogs was found sitting among some grass stems in a flooded area on April 1, 1934. Here the water was about a foot deep.

Rana catesbeiana Shaw

Bullfrogs are very common about the larger ponds and streams of the Middle West, and they are abundant in the swamps of the lower Mississippi Valley.

Arkansas—BENTON: 5 mi. E. Pea Ridge (June 7, 1934). COLUMBIA: 6 mi. S.E. Waldo (June 24, 1934). GRANT: Just N. Sheridan (June 5, 1934). HOT SPRING: 2 mi. N.E. Bismarck (June 23, 1934). LAWRENCE: 3 mi. N.W. Black Rock (June 9, 1934). LOGAN: Just W. Booneville (June 8, 1934). NEVADA: 5 mi. S. Prescott (June 24, 1934). POLK: 3 mi. E. Cherryhill (June 3, 1934). WASHINGTON: 4 mi. S. Summers (June 7, 1934). WHITE: 2 mi. S.E. Judsonia (June 9, 1934). YELL: 3 mi. N. E. Rover (June 8, 1934).

Louisiana.—ASCENSION: 1 mi. S.E. Sorrenic (July 3, 1934). CATAHOULA: 2 mi. S.W. Utility (June 15, 1934). LAFOURCHE: Raceland (July 4, 1934). NATCHITOCHES: 4 mi. S. Allen (June 16, 1934). SABINE: 3 mi. E. Pendleton Ferry (June 16, 1934).

Missouri—PEMISCOT: 4 mi. S.W. Bragg City (June 10, 1934).

Oklahoma—ALFALFA: 2 mi. W. Goltry (May 29, 1934). HUGHES: 3 mi. N. Calvin (June 2, 1934); 2 mi. W. Holdenville (June 2, 1934). LATIMER: 2 mi. N. Gowen (June 3, 1934); 6 mi. S.W. Wilburton (June 3, 1934). LINCOLN: 1 mi. S. Agra (April 2, 1934). MUSKOGEE: 3 mi. N. Boynton (May 7, 1934). OKLAHOMA: 2 mi. S. Harrah (June 2, 1934). PITTSBURG: 1 mi. N.W. Haileyville (June 3, 1934); 2 mi. W. McAlester (June 3, 1934); 3 mi. N.E. Stuart (June 2, 1934). ROGERS: 3 mi. N. Talala (April 1, 1934). WASHINGTON: 2 mi. N. Ochelata (May 6, 1934).

Rana clamitans Latreille

Green frogs are typical inhabitants of wooded glades where they live in the vicinity of ponds, lakes and streamlets. During the day time individuals often hide under boards, logs, rocks or other protecting objects above the water line or in valleys moistened by spring seepage.

Arkansas—COLUMBIA: 6 mi. N. Taylor (June 24, 1934); 6 mi. S.E. Waldo (June 24, 1934). HOT SPRING: 2 mi. N.E. Bismarck (June 23, 1934). INDEPENDENCE: Just N.E. Olyphant (June 9, 1934). MADISON: 2 mi. S. Forum (June 22, 1934). NEVADA: 5 mi. S. Prescott (June 24, 1934). NEWTON: 1 mi. N. Ponca (June 22, 1934). POLK: 2 mi. E. Cherryhill (June 3, 1934).

Illinois—KANKAKEE: Sherburnville (June 7, 1934).

Louisiana—CONCORDIA: 4 mi. E. Ferriday (July 2, 1934); 7 mi. S. W. Ferriday (June 15, 1934). LA FOURCHE: Raceland (July 4, 1934). LASALLE: 11 mi. N.W. Jena (June 16, 1934). RICHLAND: 3 mi. W. Start (June 22, 1934). SABINE: 3 mi. E. Pendleton (June 16, 1934). SAINT JAMES: 10 mi. N.W. Lutcher (July 3, 1934). WEBSTER: 1 mi. S. Couchwood (June 24, 1934); 2 mi. E. Minden (June 24, 1934). WINN: 7 mi. S.W. Winnfield (June 16, 1934).

Rana palustris Le Conte

A pickerel frog was secured 3 miles south of Palmyra, Marion County, Missouri, on June 4, 1933.

Rana pipiens Schreber

Leopard frogs occur in a wide variety of aquatic habitats in the Middle West, where they frequent roadside ponds and bar pits, sylvan pools, streams and streamlets, river banks, lake margins, marshes, boggy spring-fed areas, and mountain brooks.

Arkansas—BENTON: 1 mi. W. Garfield (June 7, 1934). BOONE: 2 mi. N. Willcockson (June 6, 1934); CLARK: 5 mi. S. Arkadelphia (June 24, 1934). CLAY: 1 mi. N.E. Datto (June 10, 1934); 4 mi. W. McDougal (June 10, 1934). COLUMBIA: 6 mi. N. Taylor (June 24, 1934); 6 mi. S.E. Waldo (June 24, 1934). CRAIGHEAD: 4 mi. E. Jonesboro (June 11, 1934). CRITTENDEN: 2 mi. S. Turrell (June 12, 1934). DALLAS: 6 mi. N. Fordyce (June 5, 1934). GREENE: 10 mi. S.E. Paragould (June 11, 1934). HOT SPRING: 6 mi. N. Malvern (June 4, 1934). INDEPENDENCE: Just N.E. Olyphant (June 9, 1934). JACKSON: 3 mi. S. Swifton (June 9, 1934). LAWRENCE: 3 mi. N.W. Black Rock (June 9, 1934). LOGAN: Just W. Booneville (June 8, 1934). MADISON: 2 mi. S. Forum (June 22, 1934). MONTGOMERY: Just E. Oden (June 4, 1934); 4 mi. N.E. Waters (June 3, 1934). NEVADA: 5 mi. S. Prescott (June 24, 1934). PULASKI: 2 mi. N.E. McAlmont (June 8, 1934). WASHINGTON: 4 mi. S. Summers (June 7, 1934). YELL: 3 mi. N.E. Rover (June 8, 1934).

Colorado—BACA: 3 mi. N.E. Bartlett (May 27, 1934).

Louisiana—CALCASIEU: 10 mi. E. Lake Charles (July 5, 1934). CATAHOULA: 2 mi. S.W. Utility (June 15, 1934). CONCORDIA: 4 mi. E. Ferriday (July 2, 1934).

Missouri—BUCHANAN: 4 mi. N. Easton (June 3, 1934). LINN: 4 mi. W. Laclede (June 4, 1933). MACON: 2 mi. W. Lingo (June 4, 1933).

Nebraska—JEFFERSON: 2 mi. N.W. Fairbury (Sept. 28, 1933); 5 mi. N.E. Thompson (May 14, 1933).

Oklahoma—ALFALFA: 2 mi. W. Goltry (May 29, 1934); 2 mi. E. Vining (April 21, 1934). GREER: 4 mi. S.E. Mangum (June 10, 1933). HUGHES: 2 mi. W. Holdenville (June 2, 1934). LATIMER: 2 mi. N. Gowen (June 3, 1934); 2 mi. E. Wilburton (June 3, 1934). LEFLORE: Just N. Page (June 3, 1934); Zoe (June 3, 1934). LINCOLN: 1 mi. S. Agra (April 2, 1934). NOWATA: 2 mi. N. Delaware (April 1, 1934). OKMULGEE: 2 mi. S. Morris (May 7, 1934). PITTSBURG: 3 mi. N.E. Stuart (June 2, 1934). ROGERS: 3 mi. N. Talala (April 1, 1934). SEMINOLE: 4 mi. E. Seminole (June 2, 1934). TULSA: 2 mi. S.E. Alsuma (May 6, 1934); 1 mi. W. Broken Arrow (May 6, 1934).

Gastrophryne carolinensis (Holbrook)

Amplexus was observed in this narrow-mouthed frog near Waters, Arkansas, on June 3. A female collected on this date had a body length of 34 mm.

Arkansas—CRAIGHEAD: 4 mi. E. Jonesboro (June 11, 1934). DALLAS: 1 mi. N. Faringdale (June 5, 1934); 1 mi. N. Fordyce (June 4, 1934). GRANT: 2 mi. N. Ico (June 5, 1934); Just N. Sheridan (June 5, 1934). MONTGOMERY: 4 mi. N.E. Waters (June 3, 1934). NEVADA: 5 mi. S. Prescott (June 24, 1934). PULASKI: North Little Rock (June 6, 1934). WASHINGTON: 4 mi. N. Cincinnati (June 7, 1934); 4 mi. S. Summers (June 7, 1934).

Louisiana.—CALCASIEU: 10 mi. E. Lake Charles (July 5, 1934). CONCORDIA: 2 mi. S.W. Ferriday (June 15, 1934). LA FOURCHE: 6 mi. N. Golden Meadow (July 5, 1934); Raceland (July 4, 1934). LINCOLN: 1 mi. W. Choudrant (June 25, 1934). SAINT CHARLES: 3 mi. N.E. Ama (July 3, 1934). SAINT MARY: 1 mi. W. Franklin (July 5, 1934). WEST FELICIANA: 1 mi. N. Laurel Hill (July 2, 1934).

Gastrophryne olivacea (Hallowell)

This prairie inhabiting narrow-mouthed frog is often taken from under flat rocks in the spring. The present records are from 6 miles southeast of Chilocco (Apr. 29, 1933), and 4 miles west of Lyman (Apr. 11, 1934), Kay County, Oklahoma.

TURTLES

Sternotherus odoratus (Gray)

Stink-pot turtles were seined from pools in the dried up bed of Silver Creek 11 miles southeast of Winfield, Cowley County, Kansas, on August 31, 1934. Additional specimens were secured from the muck of a drying roadside pool 2 miles southwest of Heavener, Le Flore County, Oklahoma, on June 3, 1934.

Kinosternon flavescens (Agassiz)

Mr. Rogers found six of these musk turtles under a small pile of drift at the edge of a dry pond in drought stricken Barber County, Kansas, on August 13, 1934, where they were buried together with the larger examples on top.

Kansas—BARBER: Lake City (April 7, 1934); Just N.E. Lake City (Rogers, August 13, 1934). KINGMAN: 2 mi. E. Calista (May 25, 1934); 1 mi. E. Midway (May 25, 1934). RENO: 2 mi. W. Hutchinson (Cheatum, August, 1933); 6 mi E. Turon (May 25, 1934). STAFFORD: Salt Marsh 7 mi. S.W. Raymond (May 26, 1934).

Oklahoma—WOODS: 7 mi. W. Carmen (May 29, 1934); Waynoka (May 29, 1934).

Chelydra serpentina (Linné)

The snapping turtles listed below were secured from pasture ponds and prairie streams in Kansas and Oklahoma.

Kansas—BARBER: 2 mi. N. Lake City (Rogers, May 27, 1934). CHAUTAUQUA: 1 mi. E. Peru (May 6, 1934). KINGMAN: 2 mi. E. Calista (May 25, 1934). RENO: 2 mi. S. Langdon (Cheatum, August, 1933).

Oklahoma—ALFALFA: 2 mi. W. Goltry (May 29, 1934). BECKHAM: 4 mi. W. Sayre (May 28, 1934). MUSKOGEE: 3 mi. N.W. Haskell (May 7, 1934). NOBLE: 7 mi. S.E. Marland (May 7, 1934). NOWATA: 2 mi. N. Delaware (April 1, 1934). PITTSBURG: 2 mi. W. McAlester (June 3, 1934).

Terrapene ornata (Agassiz)

Ornate box-turtles are often found buried or half concealed in the sand of semi-arid tracts, where they may be dug out with the foot. Farther east they often rest in holes in the ground or in tunnels or depressions under the rocks of the prairie ledges.

Colorado—PROWERS: 3 mi. S. Holly (May 27, 1934).

Kansas—BOURBON: 2 mi. S.E. Hammond (June 22, 1934). FINNEY: 2 mi. E. Kalvesta (May 26, 1934). GEARY: 3 mi. E. Junction City (May 20, 1934). GREENWOOD: 1 mi. S. Climax (March 31, 1934); 3 mi. N. Madison (May 19, 1934). HAMILTON: 3 mi. W. Syracuse (May 27, 1934). KEARNY: 3 mi. W. Lakin (May 27, 1934). KINGMAN: 2 mi. E. Calista (May 25, 1934). LINN: 1 mi. S. Pleasanton (June 22, 1934); 4 mi. N. Prescott (June 22, 1934). MARION: 3 mi. S.E. Antelope (May 13, 1934). MORTON: 4 mi. N. Elkhart (May 27, 1934). STAFFORD: 7 mi. S.W. Raymond (May 26, 1934); 7 mi. S. St. John (April 8, 1934). WABAUNSEE: 5 mi. N.W. Eskridge (May 19, 1934).

Missouri—CLARK: 3 mi. S.W. Milo (June 22, 1934).

New Mexico—DONA ANA: 15 mi. S.W. Las Cruces (Hoyle, June 22, 1933). LUNA: 6 mi. W. Deming (Hoyle, June 22, 1934).

Oklahoma—ALFALFA: 2 mi. W. Goltry (May 29, 1934). HUGHES: 2 mi. W. Holdenville (June 2, 1934). MAJOR: 5 mi. S. Sherman (May 29, 1934). MUSKOGEE: 3 mi. N.W. Haskell (May 7, 1934). NOBLE: 5 mi. E. Marland (May 7, 1934). OKLAHOMA: 2 mi. S. Harrah (June 2, 1934). PAYNE: 2 mi. E. Cushing (May 7, 1934). POTTAWATOMIE: 4 mi. W. McCloud (June 2, 1934). SEMINOLE: 6 mi. W. Seminole (June 2, 1934). TULSA: Tulsa (May 1934). WASHINGTON: 4 mi. N. Copan (May 6, 1934). WOOD: 2 mi. N.E. Waynoka (May 29, 1934).

Texas [1]—GRAY: 4 mi. S. Alanreed (May 28, 1934). POTTER: 16 mi. E. Amy (May 28, 1934). SHERMAN: 6 mi. N.E. Stradford (May 28, 1934); 5 mi. S.W. Texhoma (May 27, 1934). WHEELER: 6 mi. E. Shamrock (May 28,1934).

Terrapene triunguis (Agassiz)

These three-toed box turtles have habits similar to those of *ornata*, but they are inhabitants of more wooded districts, where they are apt to seek concealment under boards or logs. At times specimens may be seined from the water with such regular pond and creek inhabiting forms as *Chelydra serpentina* and *Pseudemys elegans*, although the primary adaptation of *Terrapene triunguis* is for terrestrial life.

Missouri—VERNON: Sheldon (June 22, 1934).

Oklahoma—MUSKOGEE: 5 mi. N. Boynton (May 7, 1934); 5 mi. N.W. Haskell (May 7, 1934). OKFUSKEE: 7 mi. E. Okemah (May 7, 1934); 1 mi. S.E. Paden

[1] Observational records of specimens crushed on the road.

(May 7, 1934). PITTSBURG: 1 mi. S.E. Alderson (June 3, 1934); 2 mi. S.E. McAlester (June 3, 1934). TULSA: Tulsa (May 7, 1934).

Chrysemys bellii bellii (Gray)

These painted terrapins are found in pasture ponds and the smaller prairie streams in the greatest abundance. Specimens were taken in a small pool of water at the side of a sand-bottomed streamlet 3 miles northeast of Bartlett, Baca County, Colorado, on May 27, 1934. Others were found imbedded in the filaments of *Spirogyra* algae in a pasture stream 2 miles east of Calista, Kingman County, Kansas, on May 25, 1933; and Dr. Cheatum took an example 2 miles southeast of Lerado, Reno County, Kansas, in August 1933.

Pseudemys elegans (Wied)

Seventeen young of this turtle were secured by feeling with the hands on a mud flat that was covered by less than a foot of water in Le Flore County, Oklahoma, on June 3, 1934.

Kansas—BARBER: 1 mi. S.E. Lake City (Rogers, August 10, 1934). KINGMAN: 2 mi. E. Calista (May 25, 1934). RENO: 2 mi. S. Lerado (Cheatum, August 1933).

Oklahoma—ALFALFA: 2 mi. W. Goltry (May 29, 1934). BECKHAM: 4 mi. W. Sayre (May 28, 1934). CREEK: 2 mi. W. Bristow (April 2, 1934). LATIMER: 2 mi. N. Gowen (June 3, 1934); 1 mi. E. Wilburton (June 3, 1934). LEFLORE: 2 mi. S.W. Heavener (June 3, 1934). WASHINGTON: 3 mi. N. Ochelata (May 6, 1934).

Amyda mutica (Le Sueur)

This soft-shelled turtle occurs in the same habitats as *spinifera* and there is some suggestion that they may be variants of the same species. Viosca has recently shown that the supposed differences between *Pseudemys elegans* and *P. troostii* are merely a matter of secondary sexual dimorphism and it is suggested that a study of primary sexual dimorphism or possibly of the mendelian distribution of the presence or absence of nuchal serration in the *mutica-spinifera* stock of *Amyda* might have taxonomic significance. Small examples of both *mutica* and *spinifera* have been observed, but the serrations of the latter form become more pronounced with age. No ecological differences in the general habitat and field behavior of *mutica* and *spinifera* are evident in Kansas.

Mr. Rogers took *mutica* on a sandbar at the junction of a small creek and Medicine River, a little less than 5 miles southeast of Lake City, Barber County, Kansas, on August 30, 1934. The form was taken on a bank of Salt River just south of Aetna in the same county on April 21, 1934. Also, on May 25, 1934, an example was secured 6 miles east of Turon, Reno County, Kansas, in a shallow sand-bottomed, algae-filled pasture streamlet.

Amyda spinifera (Le Sueur)

Mr. Rogers removed representatives of this form from the Medicine River 1 mile south of Lake City, Barber County, Kansas, on May 27, 1934. It was also taken from a sand-bottomed prairie streamlet 6 miles east of Turon, Reno County, Kansas, on May 25, 1934; and from an algae-filled pool near a stream 2 miles northeast of Cheney, Sedgwick County, Kansas, on the same date.

LIZARDS

Anolis carolinensis Voigt

This beautiful and interesting arboreal species was often found about brush piles and old saw mill sites.

Arkansas—CLEVELAND: 12 mi. N. Fordyce (June 5, 1934). COLUMBIA: 6 mi. N. Taylor (June 24, 1934).

Louisiana—ASCENSION: 3 mi. N.W. Gonzales (July 3, 1934). CALCASIEU: 2 mi. E. Edgerly (July 6, 1934). ORLEANS: New Orleans (K.S.C. Museum). SABINE: 4 mi. S.W. Many (June 16, 1934).

Crotaphytus collaris (Say)

A young collared lizard was found under a rock in a prairie ledge near Altoona, Kansas, and in trying to escape it jumped into a large spider web from which it was unable to free itself without help.

Arkansas—BENTON: 4 mi. N.E. Gateway (June 7, 1934). CARROLL: Just N. Busch (June 7, 1934).

Kansas.—BARBER: 3 mi. S. Aetna (April 21, 1934); 2 mi. S. Lake City (Rogers, August 8, 1934). BUTLER: 2 mi. E. Magna City (April 15, 1934); 2 mi. E. Rosalia (May 19, 1934). COWLEY: 1 mi. N. Floral (April 15, 1934); 1 mi. N.E. Otto (May 6, 1934); 5 mi. E. Rock (April 16, 1934); 7 mi. N. Wilmot (April 15, 1934). ELLSWORTH: 10 mi. N. Ellsworth (April 8, 1934). MARION: 3 mi. S. Antelope (May 13, 1934). MONTGOMERY: 7 mi. E. Independence (April 1, 1934). WILSON: 2 mi. W. Altoona (April 1, 1934).

New Mexico—EDDY: 5 mi. N. Carlsbad (Hoyle, June 28, 1933); 1 mi. S. Carlsbad (August 11, 1934); 20 mi. S. Carlsbad (August 11, 1934). LEA: 9 mi. N. Lovington (Hoyle, July 1, 1933).

Oklahoma—CREEK: 2 mi. W. Bristow (April 2, 1934); 1 mi. N.W. Milfay (April 2, 1934); 4 mi. S.W. Sapulpa (April 2, 1934). KAY: 4 mi. W. Lyman (April 3, 1934). LATIMER: 2 mi. N. Gowen (June 3, 1934). LINCOLN: 3 mi. S. Sac and Fox Agency (May 7, 1934). LOGAN: 3 mi. S. Guthrie (June 2, 1934). MAJOR: 6 mi. N.E. Sherman (May 29, 1934). MUSKOGEE: 3 mi. N.W. Haskell (May 7, 1934). NOBLE: 5 mi. N. Sumner (May 7, 1934). OKFUSKEE: 1 mi. W. Springhill (May 7, 1934). PAWNEE: 2 mi. N. Pawnee (April 3, 1934); 2 mi. S.E. Pawnee (April 3, 1934). PAYNE: 2 mi. E. Cushing (May 7, 1934); 4 mi. W. Quay (April 3, 1934). SEMINOLE: 5 mi. N.W. Wewoka (June 2, 1934).

Crotaphytus wislizenii Baird and Girard

Mr. Smith found one of these lizards 2 miles east of San Marcial, Socorro County, New Mexico, on August 9, 1931.

Holbrookia maculata maculata Girard

Mr. Hoyle observed one of these lizards in Lea County, New Mexico, as it jumped from a rock and caught a small grasshopper, which it soon started to swallow.

Kansas—BARBER: 4 mi. E. Aetna (Rogers, July 8, 1934); 8 mi. S.W. Lake City (Rogers, June 26, 1934). BARTON: Hoisington (McGill, 1934). KEARNY: 1 mi. W. Lakin (May 27, 1934). KINGMAN: Belmont (Albrecht, May 6, 1934). PAWNEE: 1 mi. S.E. Larned (April 8, 1934). STAFFORD: Salt marsh 7 mi. S.W. Raymond (May 26, 1934).

New Mexico—CHAVES: 7 mi. S. E. Roswell (Hoyle, June 28, 1933). GRANT: 1 mi. W. Separ (Hoyle, June 22, 1933). LEA: 4 mi. N. Lovington (Hoyle, July 1, 1933). LUNA: 2 mi. W. Cambray (Hoyle, June 22, 1933); 8 mi. W. Deming (Hoyle, June 22, 1933). TORRANCE: Gran Quivera National Park (Smith, August 11, 1931).

Oklahoma—BECKHAM: 7 mi. W. Sayre (May 28, 1934).

Holbrookia texana (Troschel)

Mr. Hoyle collected this zebra-tailed lizard 27 miles southwest of Lordsburg, Hidalgo County, New Mexico, on June 23, 1933; and Mr. Smith secured a specimen 2 miles east of San Marcial, Socorro County, in the same state on August 9, 1931.

Uta stansburiana Baird and Girard

After sunset on the evening of June 26, 1933, Mr. Hoyle found one of these little lizards on an ant hill actively feeding on small ants 2 miles northeast of La Luz, Otero County, New Mexico. Mr. Hoyle also took this species in New Mexico 3 miles southeast of Mesquite, Dona Ana County (June 21), and 8 miles west of Deming, Luna County (June 22).

Sceloporus undulatus consobrinus Baird and Girard

Spiny swifts from Payne County, Oklahoma, are intermediate in general characters, but they appear to be closer to *consobrinus* than to *undulatus*. The lateral stripes are more or less distinct and the dark spots are concentrated on the sides to a noticeable extent.

Kansas—BARBER: Salt River just S. Aetna (April 21, 1934); 2 mi. W. Medicine Lodge (June 28, 1934). BARTON: Hoisington (McGill, 1934). ELLSWORTH: 12 mi. N.E. Frederick (April 8, 1934). HARPER: 1 mi. N. Corwin (April 7, 1934). PAWNEE: 1 mi S.E. Larned (April 8, 1934). STAFFORD: Salt marsh 7 mi. S.W. Raymond (May 26, 1934); 7 mi. S. St. John (April 8, 1934).

New Mexico—DONA ANA: 2 mi. N.W. Berino (Hoyle, June 21, 1933); 3 mi. S.E. Mesquite (Hoyle, June 21, 1933). EDDY: 35 mi. S. Carlsbad (August 11, 1934). OTERO: Edge of White Sands National Monument 4 mi. W. White Water (Hoyle, June 26, 1933).

Oklahoma—BECKHAM: 1 mi. S. Sayre (May 28, 1934). PAYNE: 4 mi. W. Quay (April 3, 1934).

Sceloporus undulatus undulatus (Latreille)

A female spiny swift of this subspecies secured near Fordyce, Arkansas, was carrying eggs in the coelom on June 5.

Transitional intergradation between this form and the more western *consobrinus* is evident in Oklahoma where the ranges of the two subspecific populations (which are apparently completely separated farther north) come into contact. Specimens from Creek and Pawnee counties are very near to *consobrinus* with the lateral stripes varying from a very distinct to a readily discernible condition and often the upper lateral stripe is rather distinct while the lower one is obsolescent. The wavy dark brown cross bars on the back are more or less broken and constricted, and in some cases a rather definite tendency for them to concentrate into spots is seen.

Arkansas—CARROLL: 4 mi. S.E. Green Forest (June 7, 1934). CLARK: 2 mi. N.E. Curtis (June 24, 1934). CLEVELAND: 12 mi. N. Fordyce (June 5, 1934). COLUMBIA: 6 mi. N. Taylor (June 24, 1934); 6 mi. S.E. Waldo (June 24, 1934). DALLAS: 6 mi. N. Fordyce (June 5, 1934). GARLAND: Crystal Springs (June 4, 1934). HOT SPRING: 3 mi. N. Malvern (June 4, 1934). MONROE: 7 mi. S.W. Clarendon (May 17, 1934). MONTGOMERY: 6 mi. E. Mt. Ida (June 4, 1934); 1 mi. E. Oden (June 4, 1934); 3 mi. W. Oden (June 4, 1934). NEWTON: Ponca (June 23, 1934). POLK: 5 mi. N.E. Mena (June 3, 1934). POPE: 15 mi. N. Dover (June 6, 1934). PULASKI: 2 mi. N. Armstead (June 6, 1934). YELL: 6 mi. S.E. Ola (June 8, 1934).

Louisiana—CALCASIEU: 2 mi. E. Edgerly (July 6, 1934). LASALLE: 11 mi. N.W. Jena (June 15, 1934). OUACHITA: 1 mi. N.W. Cheniere (June 22, 1934). SABINE: 4 mi. S.W. Many (June 16, 1934); 3 mi. E. Pendleton Ferry (June 16, 1934). WEBSTER: 2 mi. N. Couchwood (June 24, 1934); 2 mi. E. Minden (June 24, 1934). WINN: 6 mi. N.W. Tullos (June 16, 1934); 1 mi. S.W. Winnfield (June 16, 1934).

Oklahoma—CREEK: 2 mi. W. Bristow (April 2, 1934); 1 mi. N.W. Milfay (April 2, 1934); 4 mi. S.W. Sapulpa (April 2, 1934). LE FLORE: 1 mi. E. Fanshawe (June 3, 1934); just N. Page (June 3, 1934). LINCOLN: 3 mi. S. Sac and Fox Agency (May 7, 1934). MUSKOGEE: 3 mi. N.W. Haskell (May 7, 1934). PAWNEE: 2 mi. S.E. Pawnee (April 3, 1934). PITTSBURG: 3 mi. S. W. Gowen (June 3, 1934).

Phrynosoma cornutum (Harlan)

On the sunny afternoon of July 1, 1933, Mr. Hoyle found a horned lizard in the shade of a fence near Lovington, New Mexico, where it was eating ants and small beetles that were crawling on a fence post.

Kansas.—BARBER: Lake City (Rogers, Aug. 20, 1934). CHAUTAUQUA: 6 mi. E. Wauneta (May 6, 1934). COWLEY: Otto (May 6, 1934). GEARY: 3 mi. E. Junction City (May 20, 1934). KINGMAN: Belmont (Albrecht, May 6, 1933).

New Mexico.—CHAVES: 7 mi. S.E. Roswell (Hoyle, June 28, 1933). HIDALGO: 29 mi. S.W. Lordsburg (Hoyle, June 23, 1933). LEA: 8 mi. N. Lovington (Hoyle, July 1, 1933).

Oklahoma.—COTTON: 1 mi. S.E. Junction City (Aug. 14, 1934.). KAY: 1 mi. S. Ponca City (May 7, 1934). MAJOR: 8 mi. N.W. Togo (May 29, 1934). NOBLE: 2 mi. N. Orlando (June 2, 1934); 2 mi. S.E. Sumner (May 7, 1934); 2 mi. S. Three Sands (June 2, 1934). OKFUSKEE: 3 mi. E. Okemah (May 7, 1934). OKLAHOMA: Crutcho (June 2, 1934). PAYNE: 3 mi. S.E. Ripley (May 7, 1934); 5 mi. S. Stillwater (May 7, 1934).

Phrynosoma douglassii hernandesi (Girard)

A shorthorn lizard was taken near Albuquerque, Bernalillo County, New Mexico, by G. R. Hepler in 1895 (Mus. Kans. St. Coll.); and Mr. Smith took a specimen in the Sacramento Mountains 4 miles west of Cloudcroft, Otero County, in the same state on August 6, 1931.

Phrynosoma modestum Girard

In 1933, Mr. Hoyle secured this lizard in New Mexico in the flat prairie 7 miles southeast of Roswell, Chaves County (June 28); and near a rock ledge above a lake 5 miles north of Carlsbad, Eddy County (June 28). Mr. Smith found specimens 2 miles east of San Marcial, Socorro County, on August 9, 1931.

Ophisaurus ventralis (Linné)

A joint-lizard was found dead in the road below a prairie ledge 6 miles northeast of Sherman, Major County, Oklahoma, on May 29, 1934.

Cnemidophorus sexlineatus perplexus Baird and Girard

A Sonoran race-runner with a bifurcated tail was collected by Mr. Hoyle at Lordsburg, New Mexico. This specimen had a slate-colored under surface when found and this turned to black in preservatives. The ventral surface of this subspecies is usually yellowish or immaculate.

New Mexico.—CHAVES: 7 mi. S.E. Roswell (Hoyle, June 28, 1933). EDDY: 3 mi. E. Artesia (Hoyle, June 28, 1933). GRANT: 1 mi. W. Separ (Hoyle, June 23,

1933); 8 mi. W. Separ (Hoyle, June 22, 1933). HIDALGO: Lordsburg (Hoyle, June 22, 1933); 27 mi. S.W. Lordsburg (Hoyle, June 23, 1933). LUNA: 2 mi. W. Cambray (Hoyle, June 22, 1933); 8 mi. W. Deming (Hoyle, June 22, 1933). OTERO: 19 mi. S.W. Alamogordo (Hoyle, June 26, 1933).

Cnemidophorus sexlineatus sexlineatus (Linné)

The copulation of the six-lined race-runner was observed in a glade near Arkadelphia, Arkansas, on June 24, 1934.

Arkansas.—BENTON: 6 mi. W. Centerton (June 7, 1934); 1 mi. W. Garfield (June 7, 1934). BOONE: 3 mi. E. Alpena Pass (June 7, 1934). CARROLL: Just S.E. Berryville (June 7, 1934). CLARK: 5 mi. S. Arkadelphia (June 24, 1934); 2 mi. N.E. Curtis (June 24, 1934). COLUMBIA: 6 mi. N. Taylor (June 24, 1934); 6 mi. S.E. Waldo (June 24, 1934). CONWAY: 2 mi. S.E. Menfee (June 6, 1934). CRAWFORD: 5 mi. S. Fort Smith (June 8, 1934). GARLAND: 2 mi. N. Mountain Valley (June 8, 1934). HOT SPRING: 3 mi. N. Malvern (June 4, 1934). INDEPENDENCE: Just N.E. Olyphant (June 9, 1934). LOGAN: Just W. Booneville (June 8, 1934). MONTGOMERY: 6 mi. E. Mt. Ida (June 4, 1934); 1 mi. E. Oden (June 4, 1934); 3 mi. W. Oden (June 4, 1934). NEVADA: 5 mi. S. Prescott (June 24, 1934). PERRY: 8 mi. S.E. Ola (June 8, 1934). POPE: 15 mi. N. Dover (June 6, 1934). PULASKI: 1 mi. S. Palarm (June 6, 1934); 4 mi. S. Palarm (June 6, 1934). WHITE: 1 mi. N.W. Russell (June 9, 1934). YELL: Just W. Havana (June 8, 1934).

Colorado.—BACA: 3 mi. N.E. Bartlett (May 27, 1934). PROWERS: Arkansas River at Holly (May 27, 1934).

Kansas.—ANDERSON: 6 mi. S. Garnett (April 1, 1934). BARBER: Lake City (Rogers, April 30, 1934). BARTON: Hoisington (McGill, 1934). COWLEY: 1 mi. N.E. Otto (May 6, 1934); 2 mi. E. Cambridge (Mar. 31, 1934). GREENWOOD: Lamont (May 19, 1934). KINGMAN: Belmont (Albrecht, May 6, 1934); 3 mi. N.W. Cheney (May 25, 1934). PAWNEE: Burdett (May 26, 1934). STAFFORD: Salt Marsh 7 mi. S.W. Raymond (May 26, 1934).

Louisiana.—CALCASIEU: 2 mi. E. Edgerly (July 6, 1934). LINCOLN: Tremont (June 25, 1934). SABINE: 4 mi. S.W. Many (June 16, 1934). WEBSTER: 3 mi. S.E. Sarepta (June 24, 1934).

Missouri.—NEWTON: 2 mi. N.W. Wentworth (June 22, 1934).

Oklahoma.—ALFALFA: 2 mi. W. Goltry (May 29, 1934). CREEK: 1 mi. S.W. Oakhurst (April 2, 1934). GARFIELD: 1 mi. S.E. Hillsdale (May 29, 1934). HUGHES: 5 mi. W. Holdenville (June 2, 1934). LATIMER: 6 mi. S.W. Wilburton (June 3, 1934). LE FLORE: 1 mi. E. Fanshawe (June 3, 1934); just N. Page (June 3, 1934). LOVE: 4 mi. N. Marietta (Mar. 16, 1934). MAJOR: 5 mi. S. Sherman (May 29, 1934). NOBLE: 8 mi. N. Perry (June 2, 1934). OKLAHOMA: 2 mi. S. Harrah (June 2, 1934). OKMULGEE: 1 mi. N.E. Dewar (May 7, 1934). PAWNEE: 2 mi. S.E. Pawnee (April 3, 1934). POTTAWATOMIE: 4 mi. E. Shawnee (June 2, 1934). SEMINOLE: 4 mi. E. Seminole (June 2, 1934). WOODS: 7 mi. W. Carmen (May 29, 1934); N. bank Cimmaron River just S. Waynoka (May 29, 1934).

Cnemidophorus tessellatus tessellatus (Say)

Mr. Hoyle collected the desert whiptail lizard in various localities in New Mexico in 1933, where he found specimens dormant and inactive on the cool morning of the rainy day of June 22. One individual discovered in the sand beneath a dried yucca stalk laid on its back as if dead, but when warmed by the hand it gradually developed signs of life.

New Mexico.—DONA ANA: 15 mi. S.W. Las Cruces (Hoyle, June 22, 1933). EDDY: 3 mi. N.E. Carlsbad (Hoyle, June 29, 1933). HIDALGO: 19 mi. S.W. Lordsburg (Hoyle, June 23, 1933). LUNA: 2 mi. W. Cambray (Hoyle, June 22, 1933); 8 mi. W. Deming (Hoyle, June 22, 1933). OTERO: 2 mi. N.E. La Luz (Hoyle, June 27, 1933).

Leiolopisma unicolor (Harlan)

Brown-backed skinks are typical inhabitants of wooded areas. They were frequently observed darting from cover to cover in the forest, or gliding under fallen leaves, between grass stems, beneath pieces of bark, or into brush heaps. Specimens were usually taken about saw dust piles at old logging sites and many were secured while we were turning over logs.

Arkansas.—CLARK: 2 mi. N.E. Curtis (June 24, 1934). CLEVELAND: 12 mi. N. Fordyce (June 5, 1934). COLUMBIA: 6 mi. N. Taylor (June 24, 1934); 6 mi. S.E. Waldo (June 24, 1934). DALLAS: 1 mi. N. Fordyce (June 4, 1934); 6 mi. N. Fordyce (June 5, 1934). GRANT: Just N. Sheridan (June 5, 1934). GREENE: 10 mi. S.E. Paragould (June 11, 1934). HOT SPRING: 3 mi. N. Malvern (June 4, 1934). INDEPENDENCE: Just N.E. Olyphant (June 9, 1934). MONTGOMERY: 6 mi. E. Mt. Ida (June 4, 1934); 9 mi. E. Mt. Ida (June 4, 1934); 3 mi. W. Oden (June 4, 1934). NEVADA: 1 mi. S. Rosston (June 24, 1934). PULASKI: 2 mi. N. Armstead (June 6, 1934); 4 mi. S. Palarm (June 6, 1934).

Louisiana.—ASCENSION: 3 mi. N.W. Gonzales (July 3, 1934). CONCORDIA: 2 mi. W. Ferriday (July 2, 1934); 2 mi. S.W. Ferriday (June 15, 1934). MADISON: 1 mi. E. Waverly (June 22, 1934). SABINE: 3 mi. E. Pendleton Ferry (June 16, 1934).

OKLAHOMA.—CREEK: 2 mi. W. Bristow (Apr. 2, 1934); 1 mi. N.W. Milfay (April 2, 1934); 2 mi. E. Sapulpa (April 2, 1934); 4 mi. S.W. Sapulpa (April 2, 1934). LEFLORE: Just N. Page (June 3, 1934). LOGAN: 1 mi. N. Mulhall (Mar. 15, 1934). OKLAHOMA: 7 mi. N. Oklahoma City (Mar. 15, 1934). PAWNEE: 2 mi. S.W. Pawnee (April 3, 1934). PAYNE: 4 mi. W. Quay (April 3, 1934).

Eumeces anthracinus (Baird)

One of these skinks with no postnasal scale and one postmental plate was secured in a rotted log 3 miles west of Oden, Montgomery County, Arkansas.

Eumeces fasciatus (Linné)

Female five-lined skinks were found coiled about egg clusters in rotted logs or stumps in Columbia County, Arkansas, on June 24, 1934 (5 eggs), and in Nevada County of the same state on the same day (8 eggs, 10 eggs). A young specimen with a body length of 27 mm. was secured on June 16, 1934, in Sabine County, Louisiana.

Arkansas.—CLARK: 2 mi. N.E. Curtis (June 24, 1934). CLEVELAND: 12 mi. N. Fordyce (June 5, 1934). COLUMBIA: 6 mi. N. Taylor (June 24, 1934); 6 mi. S.E. Waldo (June 24, 1934). DALLAS: 6 mi. N. Fordyce (June 5, 1934). GREENE: 10 mi. S.E. Paragould (June 11, 1934). INDEPENDENCE: Just N. E. Olyphant (June 9, 1934). MONROE: 7 mi. S.W. Clarendon (Parker, May 17, 1934). MONTGOMERY: 3 mi. W. Oden (June 4, 1934). NEVADA: 1 mi. S. Rosston (June 24, 1934). POLK: 3 mi. E. Cherryhill (June 3, 1934).

Kansas.—WILSON: 2 mi. E. Buffalo (April 1, 1934).

Louisiana.—CONCORDIA: 2 mi. S.W. Ferriday (June 15, 1934); 2 mi. W. Ferriday (July 2, 1934). RICHLAND: 3 mi. W. Start (June 25, 1934). SABINE: 4 mi. S.W. Many (June 16, 1934).

Oklahoma.—CREEK: 2 mi. W. Bristow (April 2, 1934); 1 mi. N.W. Milfay (April 2, 1934). 1 mi. S.W. Oakhurst (April 2, 1934). PAWNEE: 2 mi. S.E. Pawnee (April 3, 1934).

Eumeces obsoletus (Baird and Girard)

Sonoran skinks are very numerous in collections from rock ledges in the prairie in the spring, they are occasionally seen during the summer, and they become rare during the fall. This seasonal fluctuation is no doubt correlated

with the manner of living displayed by the species, which probably retreats to recesses far under ground as the surface soil dries during the summer.

Kansas.—BARTON: Hoisington (McGill, 1934). BUTLER: 2 mi. E. Rosalia (May 19, 1934). CHASE: 2 mi. S.W. Matfield Green (Apr. 9, 1934). COWLEY: 2 mi. E. Cambridge (Mar. 31, 1934); 1 mi. N.E. Otto (May 6, 1934); 5 mi. E. Rock (April 16, 1934); 7 mi. N. Wilmot (April 15, 1934). ELLSWORTH: 10 mi. N. Ellsworth (April 8, 1934). GREENWOOD: 6 mi. N.E. Climax (Mar. 31, 1934); 1 mi. S. Climax (Mar. 31, 1934). MARION: 4 mi. N.W. Burns (Mar. 30, 1934). MARSHALL: 3 mi. E. Blue Rapids (May 20, 1934); 3 mi. S. Blue Rapids (April 9, 1934); Devils Backbone 1 mi. W. Irving (April 9, 1934). MONTGOMERY: 7 mi. E. Independence (April 1, 1934). MORRIS: 1 mi. S.W. Council Grove (April 9, 1934). WABAUNSEE: 5 mi. N. Alma (May 19, 1934); 1 mi. N. W. Halifax (May 19, 1934).

Oklahoma.—KAY: 4 mi. W. Lyman (April 3, 1934). PAWNEE: 2 mi. N. Pawnee (April 3, 1934); 2 mi. S.E. Pawnee (April 3, 1934).

SNAKES

Leptotyphlops dulcis (Baird and Girard)

Mr. Rogers has recently taken this rather rare species in Barber County, Kansas. On August 2, 1934, he found it crossing a sidewalk between two oil stations in the town of Lake City, where the individual was apparently making its way toward the moderately moist sandy soil in a roadside iris bed. The time of capture was just after dark and the specimen was observed under an electric light. Several other examples of the burrowing sand snake were found 2 miles north of Lake City on May 27, 1934.

Farancia abacura (Holbrook)

All of these beautiful snakes to be reported here were found dead on the road or they had been otherwise killed and mutilated by the human inhabitants of wooded districts.

Arkansas.—GREENE: 10 mi. S.E. Paragould (June 11, 1934).

Louisiana.—ASCENSION: 1 mi. S.E. Sorrento (July 3, 1934). CALCASIEU: 3 mi. N. Toomey (July 6, 1934). SAINT JAMES: 10 mi. N.W. Lutcher (July 3, 1934). SAINT JOHN THE BAPTIST: 3 mi. N.E. Sellers (July 3, 1934). TERREBONNE: 2 mi. S.W. Gibson (July 5, 1934).

Missouri.—PEMISCOT: 4 mi. S.W. Bragg City (June 10, 1934).

Diadophis punctatus arnyi Kennicott

This subspecies was located in a snake den in Cowley County, Kansas, on March 29, 1934. The den was in a rock pile in a gully near a spring. Here ring-neck snakes were in company with numerous specimens of the larger snakes *Elaphe laeta* and *Coluber constrictor flaviventris*.

The use of the condition of the ventral dark spots is a good average criterion for the separation of *arnyi* from *strictogenys*, but atavism[2] or orthogenesis[3] in this feature occasionally gives *arnyi* the single series of black

2 *Atavism*, in the sense that I use it, means intermittent heredity due to occasional reversion to some former ancestral condition. This phenomenon may explain the presence of ancestral characters in derived stocks.

3 *Orthogenesis*, in the sense used here, means the tendency for evolution to go forward in one direction, step by step. This phenomenon may explain the occasional occurrence of traits of derived forms in the modern representatives of parent populations (species or subspecies).

ventral dots characteristic of *strictogenys*. Ordinarily *arnyi* has irregular ventral spots which may be regarded as being representative of at least two rows. Specimens of *arnyi* with the ventral coloration of *strictogenys* have been taken recently in Morris County, Kansas, and in Pawnee County, Oklahoma. In the latter locality a ring-neck snake had the 15 scale rows of *strictogenys*, but the high ventral count of 156 caused it to identify as *arnyi*.

Arkansas.—CARROLL: 3 mi. N.W. Eureka (June 7, 1934). MADISON: 2 mi. S. Forum (June 22, 1934).

Kansas.—BARBER: 2 mi. N. Lake City (May 27, 1934). COMANCHE: 1 mi. S.W. Hell's Half Acre (April 21, 1934). COWLEY: 1 mi. N. Floral (April 15, 1934); 5 mi. E. Rock (April 16, 1934); 7 mi. N. Wilmot (April 15, 1934); 6 mi. E. Winfield (March 29, 1934). ELLSWORTH: 10 mi. N. Ellsworth (April 8, 1934). GEARY: 3 mi. E. Junction City (May 20, 1934). GREENWOOD: 1 mi. S. Climax (Mar. 31, 1934). MORRIS: 4 mi. N. Council Grove (April 9, 1934); 1 mi. S.W. Council Grove (April 9, 1934); 2 mi. N. Herington (Mar. 31, 1934). WILSON: 2 mi. W. Altoona (April 1, 1934); 2 mi. E. Buffalo (April 1, 1934).

Oklahoma.—CREEK: 2 mi. W. Bristow (April 2, 1934). MURRAY: Turner State Park Arbuckle Mountains (Mar. 16, 1934). PAWNEE: 2 mi. N. Pawnee (April 3, 1934); 2 mi. S.E. Pawnee (April 3, 1934). PAYNE: 4 mi. W. Quay (April 3, 1934).

Diadophis punctatus strictogenys Cope

This ring-neck snake was obtained in a rotted log on a timbered hillside 3 miles west of Oden, Montgomery County, Arkansas, on June 4, 1934. The scale rows were 15 at the middle of the body and the black ventral spots were arranged into approximately a single row.

Heterodon contortrix (Linné)

This hog-nosed snake occurs in forest glades and in prairies, where it is most apt to be found in sandy or gravelly habitats.

Arkansas.—GRANT: 2 mi. N. Ico (June 5, 1934). MADISON: 2 mi. N.E. Clifty (June 22, 1934). POLK: 3 mi. E. Cherryhill (June 3, 1934).

Illinois.—MONROE: Waterloo (Heinze, Mar. 27, 1932).

Kansas.—BARBER: 4 mi. S. Lake City (Rogers, July 1, 1934).

Louisiana.—ASCENSION: 1 mi. S. E. Sorrento (July 3, 1934).

Heterodon nasicus Baird and Girard

This hog-nosed snake occurs in less forested areas than *contortrix*, but it shows the same tendency to select habitats where sand and gravel are present in the surface soil. One specimen was secured as it was crawling along drift about 75 feet above the edge of Lake Lakin in western Kansas; and another was found on a sand bank in the salt marsh area of south-central Kansas.

Kansas.—BARTON: Hoisington (McGill, 1934). COWLEY: 5 mi. W. Arkansas City (May 29, 1934). KEARNY: 2 mi. N.E. Lakin (May 27, 1934). STAFFORD: Salt marsh 7 mi. S.W. Raymond (May 26, 1934).

Liopeltis vernalis (Harlan)

Professor E. A. Popenoe took a smooth green snake at Raton Pass in the mountains of Las Animas County, Colorado, in June 1907 (Mus. Kan. St. Coll.).

Opheodrys aestivus (Linné)

The rough green snake is a beautiful bush inhabiting species, which occurs in forest glades of the Middle West.

Arkansas.—PULASKI: 9 mi. N. Little Rock (June 5, 1934).

Oklahoma.—LE FLORE: Just N. Page ((June 3, 1934). OKFUSKEE: 1 mi. S.E. Castle (May 7, 1934). OKLAHOMA: 4 mi. N.E. Edmond (June 19, 1934).

Coluber constrictor constrictor Linné

Black racer snakes are agile creatures, which are often encountered on the forest floor as well as in glades and cultivated areas.

Arkansas.—MISSISSIPPI: 3 mi. N. Manila (June 10, 1934). NEWTON: 11 mi. N.W. Lurton (June 6, 1934).

Louisiana.—ACADIA: 1 mi. W. Estherwood (July 5, 1934). ASCENSION: 3 mi. N.W. Gonzales (July 3, 1934); 1 mi. S.E. Sorrento (July 3, 1934). EAST BATON ROUGE: 5 mi. N. Alsen (July 2, 1934). JEFFERSON: Grand Isle (July 4, 1934).

Coluber constrictor flaviventris Say

A female blueracer was found dead in the road with eggs exposed from the coelom in Pawnee County, Kansas, on May 26. Young individuals with the initial color pattern were found in a snake den in Cowley County, Kansas, on March 29, in company with *Elaphe laeta* and *Diadophis punctatus arnyi*. The adults were associated with large bullsnakes *(Pitouphis sayi sayi)* in another den on a prairie hillside. The nature of the dens will be discussed below under *Elaphe laeta* and *Pitouphis sayi sayi*.

Mr. Rogers placed a small prairie king snake *(Lampropeltis calligaster)* in a cage with an adult blueracer snake on August 31 and the *Coluber* immediately attacked the smaller snake, swallowing it tail first.

Arkansas.—BOONE: 2 mi. E. Alpena Pass (June 7, 1934). CARROLL: Just S.E. Berryville (June 7, 1934). CLEVELAND: 17 mi. N. Fordyce (June 5, 1934). CRAWFORD: 9 mi. S. Fort Smith (June 8, 1934). MADISON: 3 mi. N. Forum (June 22, 1934). POPE: 6 mi. S. Simpson (June 6, 1934). SALINE: 5 mi. N. Ico (June 5, 1934). WASHINGTON: Just E. Summers (June 7, 1934).

Colorado.—BACA: 3 mi. N.E. Bartlett (May 27, 1934); 2 mi. E. Stonington (May 27, 1934). PROWERS: 1 mi. E. Holly (May 27, 1934).

Kansas.—ATCHISON: 2 mi. E. Shannon (June 21, 1934). BARBER: Lake City (Aug. 12, 1934); 1 mi. W. Sun City (July 10, 1934). BARTON: Hoisington (McGill, 1934). BUTLER: 2 mi. E. Magna City (April 15, 1934). COWLEY: 5 mi. E. Rock (April 16, 1934); 7 mi. N. Wilmot (April 15, 1934); 1 mi. N.E. Otto (May 6, 1934); 6 mi. E. Winfield (Mar. 29, 1934). ELLSWORTH: 12 mi. N.E. Frederick (April 8, 1934). GEARY: 6 mi. N.E. Fort Riley (May 20, 1934); 3 mi. E. Junction City (May 20, 1934). GREENWOOD: 1 mi. S. Climax (Mar. 31, 1934). HAMILTON: Syracuse (May 27, 1934). KEARNY: 3 mi E. Kendall (May 27, 1934). LYON: 8 mi. N.E. Emporia (May 19, 1934). MARSHALL: 3 mi. S. Blue Rapids (April 9, 1934). MORRIS: 1 mi. S.W. Council Grove (April 9, 1934). PAWNEE: 2 mi. W. Rozel (May 26, 1934); 1 mi. W. Burdett (May 26, 1934). RILEY: 2 mi. N. Cleburne (May 20, 1934). STAFFORD: Salt marsh 7 mi. S.W. Raymond (May 26, 1934).

Michigan.—LIVINGSTON: 2 mi. S.W. Gregory (July 22, 1934).

Oklahoma.—BECKHAM: 1 mi. S. Sayre (May 28, 1934); 4 mi. W. Sayre (May 28, 1934). CUSTER: 6 mi. N.W. Custer (May 29, 1934). KAY: 4 mi. W. Lyman (April 8, 1934). LATIMER: 2 mi. N. Gowen (June 3, 1934). LE FLORE: Just N. Page (June 3, 1934). LINCOLN: 9 mi. N. Stroud (May 7, 1934). NOBLE: 5 mi. N. Sumner (May 7, 1934). PAWNEE: 2 mi. S.E. Pawnee (April 3, 1934). PAYNE: 5 mi. S. Stillwater (May 7, 1934).

Coluber flagellum flagellum Shaw

Black whipsnakes are commonly found under flat rocks in prairie ledges in the spring.

Arkansas.—CRAWFORD: 5 mi. S. Fort Smith (June 8, 1934). SALINE: 11 mi. S. Little Rock (June 5, 1934); 2 mi. E. Whittington (June 8, 1934).

Oklahoma.—CREEK: 4 mi. S.W. Sapulpa (April 2, 1934). PAWNEE: 2 mi. N. Pawnee (April 3, 1934).

Coluber flagellum flavi-gularis (Hallowell)

Prairie whipsnakes are common inhabitants of pastures and cultivated fields where they often hide in rock ledges, in rock piles, or under large fallen signs of tin or wood.

Kansas.—BARBER: 1 mi. E. Lake City (Rogers, Aug. 26, 1934); 3 mi. N.W. Lake City (Rogers, Aug. 25, 1934).

Oklahoma.—ALFALFA: 3 mi. E. Carmen (May 29, 1934). CUSTER: 3 mi. N.E. Butler (May 28, 1934).

Elaphe laeta (Baird and Girard)

A den containing over a dozen of these snakes (young to adult) was located on March 29, 1934, in a ravine 6 miles east of Winfield, Kansas, on a warm day following a cold period. The snake den was at the base of a south slope in a clump of oak trees above a small stream. A spring that flows all year was situated near by and much rock was in evidence. At one point a vertical rock was scaled off to a height of about four feet and many snakes were revealed, including young *Coluber constrictor flaviventris* and some adults of *Diadophis punctatus arnyi* in addition to the present species.

Arkansas.—CARROLL: 4 mi. W. Green Forest (June 7, 1934).

Kansas.—COWLEY: Just N. Rock (May 20, 1934); 7 mi. N. Wilmot (April 15, 1934); 6 mi. E. Winfield (March 29, 1934). ELLSWORTH: 12 mi. N.E. Frederick (April 8, 1934). MARSHALL: 3 mi. E. Blue Rapids (May 20, 1934). MORRIS: 1 mi. S.W. Council Grove (April 9, 1934). WABAUNSEE: 3 mi. E. Wabaunsee (May 19, 1934).

Oklahoma.—GARFIELD: 5 mi. S.E. Hunter (May 29, 1934).

Elaphe obsoleta (Say)

A pair of snakes were found dead in the road near Orlando, Oklahoma, on June 2. The smaller specimen was a female in the *confinis* stage of color pattern ontogeny while the larger one was a male in the black *"obsoleta"* phase of development. There is apparently no reason why these so-called "subspecies" should be longer recognized as valid.

Arkansas.—BENTON: 3 mi. E. Decatur (June 7, 1934); 3 mi. N.E. Gateway (June 7, 1934). CARROLL: Just S. Busch (June 7, 1934). CONWAY: Just W. Morrilton (June 6, 1934). MADISON: 2 mi. S. Forum (June 22, 1934). MONTGOMERY: 5 mi. E. Mt. Ida (June 4, 1934). NEWTON: 4 mi. N. Jasper (June 6, 1934). PULASKI: 3 mi. S.E. Armstead (June 6, 1934). SALINE: 11 mi. S. Little Rock (June 5, 1934). YELL: 3 mi. S.W. Plainview (June 8, 1934).

Kansas.—RILEY: 2 mi. N. Stockdale (April 9, 1934).

Oklahoma.—NOBLE: 5 mi. N. Orlando (June 2, 1934). PAYNE: 6 mi. E. Cushing (May 7, 1934). TULSA: 3 mi. E. Bixby (May 7, 1934).

Arizona elegans elegans Kennicott

Two of these snakes were found in the road near wheat fields. One was secured 5 miles north of Turon, Reno County, Kansas, on May 25, 1934;

and the other was taken 6 miles northeast of Waynoka, Woods County, Oklahoma, on May 29, 1934.

Pituophis sayi sayi (Schlegel)

A bullsnake collected near Preston, Minnesota, showed the following characteristics: 217 ventral scutes, 46 subcaudals, 29 scale rows at the middle of the body, 8 upper labials, 12 lower labials, 42 dorsal saddles of dark color on the body and 12 on the tail.

On the sunny afternoon of March 29 a number of large bullsnakes and several adult blueracers *(Coluber constrictor flaviventris)* were found basking on the south slope of a hill at approximately the military crest. Just below the mass of snakes a hole about three inches in diameter extended straight downward for a distance of over a foot and then it zig-zagged through some buried rocks. While four bullsnakes and three of the more agile blue racers were being captured an uncounted number of snakes made their way into this substantial retreat from which they were not obtained. It is assumed that the snakes had been in this den during the winter.

Colorado.—PROWERS: Arkansas River at Holly (May 27, 1934).

Kansas.—BARBER: 5 mi. N.E. Aetna (Rogers, June 26, 1934); 1 mi. S. Deerhead (July 20, 1934); 4 mi. S.E. Lake City (Aug. 28, 1934). BARTON: 3 mi. W. Ellinwood (May 26, 1934); Lake Barton 4 mi. S. Hoisington (McGill, 1934). BOURBON: 2 mi. E. Fort Scott (June 22, 1934). COWLEY: 1 mi. W. Cambridge (Mar. 31, 1934); 1 mi. N.E. Otto (May 6, 1934); 6 mi. E. Winfield (Mar. 29, 1934). FINNEY: 4 mi. E. Essex (May 26, 1934). GEARY: 1 mi. E. Ft. Riley (May 20, 1934); 3 mi. E. Junction City (May 20, 1934). GREENWOOD: 2 mi. S. Virgil (May 19, 1934) HAMILTON: 1 mi. W. Coolidge (May 27, 1934); 3 mi. E. Syracuse (May 27, 1934); 3 mi. W. Syracuse (May 27, 1934). HODGEMAN: 4 mi. N.E. Grayling (May 26, 1934); 3 mi. S.W. Hanston (May 26, 1934); Jetmore (May 26, 1934). JACKSON: 2 mi. E. Netawaka (June 21, 1934). KEARNEY: 3 mi. E. Lakin (May 27, 1934). KINGMAN: 3 mi. N.W. Cheney (May 25, 1934); 3 mi. W. Kingman (Cheatum, Aug. 1933). LYON: 5 mi. S. Admire (May 19, 1934). MARSHALL: 4 mi. W. Lillis (May 20, 1934). NEMAHA: 2 mi. E. Corning (June 21, 1934). POTTAWATOMIE: 3 mi. N. Blaine (May 20, 1934); Wamego (May 19, 1934). RENO: 1 mi. S. Penalosa (Cheatum, Aug. 1933). RICE: Silica (May 26, 1934). RILEY: 3 mi. S. Randolph (June 19, 1934). WABAUNSEE: 5 mi. N. Alma (May 19, 1934).

Minnesota.—FILLMORE: 1 mi. E. Preston (July 19, 1934).

Nebraska.—KNOX: 7 mi. N. Crofton (July 17, 1934).

Oklahoma.—ALFALFA: 3 mi. E. Carmen (May 29, 1934). BECKHAM: 4 mi. N.E. Elk City (May 28, 1934). GARFIELD: 1 mi. S.E. Hillsdale (May 29, 1934). KAY: Grainville (May 29, 1934); 101 Ranch (June 2, 1934); 5 mi. S. Ponca City (May 7, 1934). LOGAN: 2 mi. N. Guthrie (June 2, 1934). NOBLE: 4 mi. N. Billings (May 29, 1934). OSAGE: 3 mi. E. Burbank (April 3, 1934). WOODS: 4 mi. W. Capron (April 21, 1934); N. bank Cimmaron R. just S. Waynoka (May 29, 1934).

Lampropeltis calligaster (Harlan)

As reported above under *Coluber constrictor flaviventris*, a young prairie king snake was swallowed by an adult blueracer near Lake City, Kansas, on August 31. An adult six-lined race-runner *(Cnemidophorus sexlineatus sexlineatus)* was regurgitated from the stomach of a half grown prairie king snake at Lamont, Kansas, on May 19.

Arkansas.—BENTON: 2 mi. N.E. Siloam Springs (June 7, 1934). WHITE: 1 mi. N.E. McRae (June 8, 1934).

Kansas.—BARBER: Lake City (Rogers, Aug. 31, 1934). COWLEY: 1 mi. N.E. Otto (May 6, 1934). GREENWOOD: Lamont (May 19, 1934).

Lampropeltis getulus holbrooki Stejneger

A medium-sized salt and pepper snake when placed in a cage with a green snake as long as itself, swallowed the latter species *(Opheodrys aestivus)*, head first, according to Mr. Hoyle, who rescued the slender green snake once by pulling it out of the king snake's alimentary canal. About three days later, upon the second attempt the green snake was devoured beyond all hopes of rescue.

Arkansas.—MONTGOMERY: 7 mi. N.W. Mauldin (June 4, 1934); 3 mi. W. Oden (June 4, 1934). PULASKI: 1 mi. S. Palarm (June 6, 1934).

Kansas.—COWLEY: 2 mi. E. Cambridge (Mar. 31, 1934); 1 mi. N.E. Otto (May 6, 1934); 7 mi. N. Wilmot (April 15, 1934). MARION: 3 mi. S.E. Antelope (May 13, 1934).

Louisiana.—EAST BATON ROUGE: 5 mi. N. Alsen (July 2, 1934). RICHLAND: 3 mi. E. Rayville (June 25, 1934).

Oklahoma.—HUGHES: 2 mi. W. Holdenville (June 2, 1934). KAY: 4 mi. W. Lyman (April 3, 1934).

Lampropeltis getulus nigra (Yarrow)

This snake was secured 4 miles southwest of Bragg City, Pemiscot County, Missouri, on June 10, 1934.

Lampropeltis triangulum amaura Cope

This coral king snake was crawling at the edge of a cypress swamp in the lower Mississippi Valley 2 miles southwest of Ferriday, Concordia Parish, Louisiana, on June 15, 1934. The red bands tended to approach on the belly but they did not unite ventrally in the individual captured.

Lampropeltis triangulum syspila (Cope)

This coral king snake was collected in a shale bed in the sparsely wooded prairie 1 mile southwest of Council Grove, Morris County, Kansas, on April 9, 1934.

Lampropeltis triangulum triangulum (Lacépède)

A milk snake was captured in a prairie habitat 3 miles northeast of Clinton, in Washtenaw County, Michigan, on July 30, 1931. Another example was found 3 miles southeast of Sylvan, Richland County, Wisconsin, on July 19, 1934.

Rhinocheilus lecontei Baird and Girard

This beautiful species was collected in the semiarid sage brush desert 3 miles north of Elkhart, Morton County, Kansas, on May 27, 1934.

Sonora semiannulata Baird and Girard

These snakes are often found in rather barren prairie sections under rocks in the spring, but they are rarely seen in the summer and the fall.

Kansas.—BARBER: 2 mi. N. Lake City (Rogers, May 27, 1934). COMANCHE: 3 mi. S.E. Arrington (April 21, 1934) WILSON: 2 mi. W. Altoona (April 1, 1934).

Oklahoma.—CREEK: 2 mi. W. Bristow (April 2, 1934). KAY: 4 mi. W. Lyman (April 3, 1934). LOGAN: 1 mi. N. Mulhall (Mar. 15, 1934). PAWNEE: 2 mi. N. Pawnee (April 3, 1934); 2 mi. S.E. Pawnee (April 3, 1934).

Natrix cyclopion (Duméril and Bibron)

This inornate water snake was found in Louisiana, 1 mile west of Crowley, Acadia Parish, on July 5, 1934; and 2 miles west of Jennings, Jefferson Davis Parish, on the same date.

Natrix erythrogaster erythrogaster (Forster)

Red-bellied watersnakes were obtained along the edge of brush-filled stagnant pools in a creek bed 10 miles southeast of Paragould, Greene County, Arkansas, on June 11, 1934; and in a marsh 6 miles north of Golden Meadow, La Fourche Parish, Louisiana, on July 5, 1934.

Natrix erythrogaster transversa (Hallowell)

Like true *erythrogaster,* this snake has no dark markings on the ventral surface in typical specimens. In general scutellation both *erythrogaster* and *transversa* often overlap *sipedon* or agree with it entirely, and since the ventral dark markings in *sipedon* are obsolescent in some examples other morphological transition may be postulated. While adults of *erythrogaster* have reddish or copper-colored under parts, those of *transversa* are always yellowish or immaculate below. The young are practically indistinguishable.

Mr. Rogers found this snake feeding on leopard frogs *(Rana pipiens)* in Barber County, Kansas, on April 7, and a watersnake of this species shot in the head in Polk County, Arkansas, on June 3, regurgitated a living toad *(Bufo woodhousii)* that started to hop away after being released.

Arkansas.—POLK: 3 mi. E. Cherryhill (June 3, 1934).

Kansas.—BARBER: Lake City (Rogers, April 7, 1934); mouth of Sand Creek 2 mi. S.E. Lake City (Rogers, Aug. 15, 1934); 5 mi. N. E. Lake City (Rogers, July 20, 1934). COWLEY: 7 mi. N. Wilmot (Apr. 15, 1934). HARPER: 1 mi. N. Corwin (April 7, 1934).

Oklahoma.—TULSA: 2 mi. S.E. Alsuma (May 6, 1934).

Natrix fasciata confluens Blanchard

The dorsal saddles of this subspecies tend to become obsolete in the largest individuals, but they are very distinct in the young and even in the ordinary adults. An individual secured near Estes, Arkansas, on June 4, had a toad *(Bufo terrestris)* in its mouth at the time of capture, so two species were taken at once.

Arkansas.—GREENE: 10 mi. S.E. Paragould (June 11, 1934). HOT SPRING: 2 mi. N. Estes (June 4, 1934).

Louisiana.—RICHLAND: 3 mi. W. Start (June 25, 1934). SAINT JOHN THE BAPTIST: 3 mi. N.E. Sellers (July 3, 1934). WINN: 7 mi. S.W. Winnfield (June 16, 1934).

Natrix grahamii (Baird and Girard)

A clump of six of these relatively attractive little water snakes was taken in sun-warmed tepid water beneath the overhanging boughs of willow trees at the edge of a large pond 2 miles south of Alsuma, Tulsa County, Oklahoma, on the evening of May 6, 1934. The water was shallow and the snakes were near a brush accumulation and not far from a small hole in the bank,

which presumably led to an underground retreat. All six of the snakes were grabbed at one time.

Natrix rhombifera (Hallowell)

This unattractive watersnake is rather inquisitive at times. When an individual retreats into a hole in the ground, a few minutes waiting may be rewarding by one seeing the creature stick its head out of the opening. If the snake believes that the coast is clear it will soon come out into the open in most cases, but upon any disturbance it will beat a hasty retreat.

Louisiana.—CATAHOULA: 2 mi. S.W. Utility (June 15, 1934). CONCORDIA: 5 mi. S.W. Ferriday (June 15, 1934). MADISON: 10 mi. E. Tallulah (June 29, 1931). VERNON: 4 mi. S.E. Leesville July 4, 1934).

Oklahoma.—LINCOLN: 1 mi. S. Agra (April 2, 1934). TULSA: 1 mi. W. Broken Arrow (May 6, 1934).

Natrix sipedon sipedon (Linné)

These watersnakes are very common about ponds and streams in the Middle West. They are often found in the same pools as *transversa* and *erythrogaster*. They are probably most active at dusk and dawn, but prowling individuals may be located at almost any hour of the day or night.

Arkansas.—CRITTENDEN: 2 mi. S. Turrell (June 12, 1934). LAWRENCE: 3 mi. N.W. Black Rock (June 9, 1934). MADISON: 2 mi. S. Forum (June 22, 1934). NEWTON: 1 mi. N. Ponca (June 22, 1934). POPE: 15 mi. N. Dover (June 6, 1934).

Kansas.—BARBER: 3 mi. N. Lake City (Rogers, Aug. 11, 1934); mouth of Sand Creek 2 mi. S.E. Lake City (Rogers, Aug. 15, 1934). COWLEY: 5 mi. E. Rock (April 16, 1934); 7 mi. N. Wilmot (April 15, 1934). MORRIS: 1 mi. S.W. Council Grove (April 9, 1934).

Louisiana.—MADISON: 6 mi. E. Tallulah (June 29, 1931).

Storeria dekayi (Holbrook)

These little brown wood snakes were secured in Kansas at the base of an old hollow tree stump 4 miles north of Lake City, Barber County, on April 1, 1934 (Rogers); and underneath a rotted log just above the Arkansas River 2 miles northeast of Oxford, Sumner County, on October 14, 1934. Mr. Schaefer took a specimen at Madison, Dane County, Wisconsin, on April 9, 1934.

Potamophis striatulus (Linné)

Two of these brown snakes were collected on the east slope of a sparsely wooded tract under flat rocks 1 mile northwest of Milfay, Creek County, Oklahoma, on April 2, 1934. Both examples had 16 scale rows around the middle of the body, not 17 as Blanchard found in his specimens while preparing his key.

Thamnophis lineatus (Hallowell)

Kansas specimens of this ribbon snake were taken under flat rocks in prairie ledges 2 miles southwest of Matfield Green, Chase County, on April 9, 1934; and 1 mile northeast of Otto, Cowley County, on May 6, 1934. An additional example was secured 2 miles southeast of Pawnee, Pawnee County, Oklahoma, on April 3, 1934.

Thamnophis marcianus (Baird and Girard)

Mr. Rogers captured this garter snake at the edge of an irrigation ditch in a vegetable garden at Lake City, Barber County, Kansas, on June 25, 1934.

Thamnophis radix radix (Baird and Girard)

This snake is a typical prairie inhabiting species, which often lives in fence rows, sparse woods, gardens, and pastures.

Colorado.—BACA: 3 mi. N.E. Bartlett (May 27, 1934).

Iowa.—CLAY: 3 mi. N. Spencer (July 24, 1934).

Kansas.—BARBER: Medicine River 2 mi. S.W. Lake City (Aug. 12, 1934). BARTON: Redwing (April 8, 1934). HAMILTON: 1 mi. E. Coolidge (May 27, 1934). RENO: 6 mi. E. Turon (May 25, 1934). WABAUNSEE: 1 mi. N.W. Alta Vista (April 9, 1934).

South Dakota.—YANKTON: 5 mi. N.E. Utica (July 17, 1934).

Wisconsin.—DANE: Madison (Schaefer, April 9, 1934).

Thamnophis sauritus proximus (Say)

These ribbon snakes are most abundant in extensive marshy areas that are filled with aquatic vegetation, such as reeds and cat-tails. They are often found in the reeds and grasses near shallow, meandering prairie streams as well, especially in the vicinity of those with sandy and gravelly bottoms.

Arkansas.—SALINE: 4 mi. N. Ico (June 5, 1934).

Illinois.—JACKSON: Swallow Hollow (Heinze, May 1, 1932). MADISON: Horseshoe Lake (Heinze, April 24, 1932).

Kansas.—BARBER: Sand Creek 2 mi. S.E. Lake City (Rogers, Aug. 19, 1934). KEARNEY: 3 mi. E. Lakin (May 27, 1934).

Louisiana.—JEFFERSON DAVIS: 1 mi. S.E. Jennings (July 5, 1934). SAINT MARY: 2 mi. W. Berwick (July 5, 1934).

Oklahoma.—BECKHAM: 1 mi. S. Sayre (May 28, 1934); 4 mi. W. Sayre (May 28, 1934).

Thamnophis sirtalis parietalis (Say)

This form has about the same ecological distribution as *radix*, but it may be a little more sensitive to lack of moisture in the surface soil than that species. It is, however, not as partial to swampy areas as *proximus*.

Kansas.—BARBER: 6 mi. S. Lake City (Rogers, June 26, 1934). KINGMAN: 2 mi. E. Calista (May 25, 1934). LYON: 7 mi. N. E. Emporia (May 19, 1934). MORRIS: 1 mi. S.W. Council Grove (April 9, 1934).

Thamnophis sirtalis sirtalis (Linné)

This eastern garter snake lives in forest glades, yards, rock piles, and other places where protection is afforded. It is much like *parietalis* in its ecological distribution and behavior.

Illinois.—JACKSON: Swallow Hollow (Heinze, April 24, 1932).

Louisiana.—CONCORDIA: 4 mi. E. Ferriday (July 2, 1934). MADISON: 2 mi. E. Tallulah (June 29, 1931).

Michigan.—LIVINGSTON: 3 mi. S. Howell (July 22, 1934).

Minnesota.—HOUSTON: 3 mi. S.E. La Crescent (July 18, 1934).

Wisconsin.—DANE: Madison (Schaefer, April 9, 1934). VERNON: 5 mi. S.E. Viroqua (July 19, 1934).

Tantilla gracilis gracilis Baird and Girard

In the prairie the sand snake is usually found under rocks in ledges either where there are no trees or in glades, but farther east it occurs in rockless woods, where specimens may be removed from decaying stumps and logs.

Arkansas.—MONTGOMERY: 3 mi. W. Oden (June 4, 1934).

Kansas.—COWLEY: 1 mi. N. Floral (April 15, 1934). MONTGOMERY: 7 mi. E. Independence (April 1, 1934). WILSON: 2 mi. W. Altoona (April 1, 1934).

Oklahoma.—CREEK: 2 mi. W. Bristow (April 2, 1934); 1 mi. N. W. Milfay (April 2, 1934); 1 mi. S.W. Oakhurst (April 2, 1934); 2 mi. E. Sapulpa (April 2, 1934). 4 mi. S.W. Sapulpa (April 2, 1934). KAY: 4 mi. W. Lyman (April 3, 1934). LINCOLN: 3 mi. N. Chandler (April 2, 1934). PAWNEE: 2 mi. N. Pawnee (April 3, 1934); 2 mi. S.E. Pawnee (April 3, 1934). PAYNE: 4 mi. W. Quay (April 3, 1934).

Agkistrodon mokasen mokasen Beauvois

The copperhead snake was taken 5 miles east of Rock, Cowley County, Kansas, on April 16, 1934.

Agkistrodon piscivorus (Lacépède)

This relatively aquatic species was found about the marshes and streams, where it was usually in a position to retreat into drift or holes in the bank. Like many frogs, these snakes are best taken at night with the aid of a flashlight.

Arkansas.—MONROE: 9 mi. S.W. Clarendon (Parker, May 17, 1934).

Louisiana.—CONCORDIA: 7 mi. S.W. Ferriday (June 15, 1934). SAINT JAMES: 10 mi. N.W. Lutcher (July 3, 1934). SAINT MARY: 1 mi. W. Franklin (July 5, 1934). WEBSTER: 2 mi. E. Minden (June 24, 1934). WEST FELICIANA: 1 mi. N. Wakefield (July 2, 1934).

Sistrurus catenatus catenatus (Rafinesque)

This small prairie rattlesnake was found under a rock in a prairie ledge 1 mile northeast of Otto, Cowley County, Kansas, on May 6, 1934.

Crotalus confluentus confluentus Say

The large prairie rattlesnake was secured in a pasture 3 miles west of Syracuse, Hamilton County, Kansas, on May 27, 1934.

SOUTHWESTERN COLLEGE,
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STUDIES IN PALEOZOIC CORALS

III.—A Revision of Some Mississippian Zaphrentids*

BRANDON H. GROVE

A.—Introduction

The existing classification of the tetracorals of the Mississippian period in North America has resulted largely from the accumulation of numerous isolated descriptions of species, collected from a wide area, and delineated sporadically through a considerable period of time. With the progressive depletion of the number of obviously new forms has come a waning of interest, and the Mississippian corals have been permitted to remain a group whose principal basis for unification has been their common occurrence in strata of essentially the same age.

It is a tribute to Milne-Edwards and Haime that the first extensive treatment of American Mississippian corals should be at the hands of these French authors. In their *Polypiers Fossiles des Terrains Palaeozoiques*, published in 1851, five genera and fourteen species of cup corals are described from the Mississippian of North America, and in 1860 Milne-Edwards redescribed all these and added four new species in volume three of his *Histoire Naturelle des Coralliaires*.

The common usage of the French treatises as reference texts has perhaps led most of the American workers who dealt with Mississippian corals to attempt to refer their species to genera contained therein, rather than to derive their taxonomy from a completely independent analysis of the material studied.

In the Twelfth Annual Report of the Hayden Survey, published in 1878, C. A. White described a number of Mississippian corals from Iowa and Missouri, thus supplementing the single species described from Iowa by James Hall in 1858.[1] White's dependence upon the work of Edwards and Haime as a guide to the determination of genera is shown both by his nomenclature and the manner in which his descriptions are modelled.[2] A similar tendency is manifest in the work of Amos Worthen, whose descriptions of corals from the Mississippian strata of Illinois and the adjacent states, published in 1890, is the first American work dealing with any considerable number of forms. The eighteen species described by Worthen are referred

* Parts I and II of these studies appeared in this journal, **15**, (2): 97-137, 1934.

1 Hall, J., Geol. Iowa, **1** (2): 650, pl. 22, 1858.

2 White, C. A. Cont. to Invert. Paleon., No. 8; 156, in 12th Ann. Rept. Hayden Survey, 1878.

to genera established by Milne-Edwards and Haime, sixteen species being placed in *Zaphrentis* alone.[3]

A year after the appearance of Worthen's work, S. A. Miller published a similar discussion of Mississippian corals from Missouri and Indiana. Here again we find that nine of the eleven species of tetracorals described are referred to the genera *Amplexus* and *Zaphrentis*, although Miller also created the genus *Cystelasma* and placed two species in it.[4]

In 1894 Charles R. Keyes, as state Geologist of Missouri, described the corals of that area. His discussion, however, amounts to little more than abstracts of the descriptions of previous writers. [5] The work of Miller in Indiana was continued during the years 1898 to 1906 by the analogous studies of Greene[6] and Beede.[7]

The first considerable step toward the independent derivation of a generic taxonomy from the study of American material is found in the generic revisions published in 1900 by George B. Simpson.[8]

This work resulted in the creation of 18 genera of Paleozoic corals based solely upon American species. At least five of these genera are directly applicable to Mississippian forms, notably, *Meniscophyllum, Hapsiphyllum, Triplophyllum, Schoenophyllum,* and *Homalophyllum.* The immediate consequence of Simpson's work has been the introduction of a dual terminology into the writings of later American paleontologists, some having elected to retain the original nomenclature, others having recognized Simpson's genera. This is especially true in regard to the genera *Hapsiphyllum, Triplophyllum,* and *Homalophyllum,* which were separated by Simpson from the genus *Zaphrentis.*

In 1914 Marjorie O'Connell published an analysis of the genus *Zaphrentis,* giving full support to the genera created from *Zaphrentis* by Simpson as well as a clear delineation of *Zaphrentis* itself.[9]

Recent years have seen many descriptions of Mississippian tetracorals from America, chiefly as members of local faunal lists, but no attempt has been made to unify the species under clearly depicted genera. Philosophical surveys of the relationships, occurrences, and trends of the Amrican forms have been even more conspicuously lacking.

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3 Worthen, A. H., Geology of Illinois, **8**: 71-82, 1890.

4 Miller, S. A., 17th Ann. Rept. Indiana Dept. Geol. Nat. Res.: 616-623, 1892.

5 Keyes, C. R. Missouri State Geol. Surv., **4**: 104-124, 1895.

6 Greene, G. K., Contributions to Indiana Paleontology, **1**, pts. 1-20. 1898-1904.

7 Beede, J. W., 30th Ann. Rept. Indiana Dept. Geol. Nat. Res.: 1201-1218, 1905-1906.

8 Simpson, G. B., New York State Mus. Bull. **39**: 199-222, 1900.

9 O'Connell, M., Ann. Acad. Sci. New York, **23**: 177-92, 1913.

B. — Systematic

Class ANTHOZOA Gistl.

Order TETRASEPTATA Grabau

Sub-order PROTEROSEPTATA Grabau

Family *Zaphrentidae* M.—E. & H. (emend. Grabau)

Simple conical to cylindrical corals derived from the *Streptelasmaidae*, with the primitive types of which the early stages of the *Zaphrentidae* always agree. Septa quadripartite in the earlier stages, becoming more or less radial in the later; sometimes twisting at the center, in others (highly specialized types) assuming a breviseptal (amplexoid) character, i. e., falling short of the center. Fossula always well developed, in more specialized types becoming a siphono-fossula. Cardinal septum usually very short in the adult, or even almost completely aborted; the secondary septa on either side often retaining their pinnate arrangement, or bending towards each other. Carinae present in a few specialized types. Tabulae well developed in all but the primitive types where they may be wanting. Dissepiments generally well developed in the more typical genera. No columella, but a slight twisting of the septa in the center may suggest a streptocolumella. Range: from Silurian (?) to Carboniferous[10].

Genus *Triplophyllum* Simpson

Triplophyllum. Simpson, New York State Mus. Bull. **39**: 209, figs. 26-27, 1900.

Triplophyllum. Simpson, Univ. State New York, State Mus. Rept. 54, **3**: 209, figs. 26-27, 1902.

Tripliphyllum. O'Connell, Ann. New York Acad. Sci., **23**: 192, 1913.

Genotype.—Zaphrentis terebrata Hall, 12th Ann. Rept. Ind. Dept. Geol. Nat. Hist.: 316, 1883. Onondaga limestone, Falls of the Ohio.

Example.—Zaphrentis centralis Edwards and Haime, Mon. polyp. terr. pal.: 328, pl. 3, fig. 6.

Description.—In segregating the genus *Triplophyllum* from the genus *Zaphrentis*, Simpson characterized it as follows:

This genus has the same appearance and mode of growth as *Zaphrentis*, but in addition to the septal fovea there are two lateral foveae. The microscopic character is also different. In *Zaphrentis* the calcareous fibres of the septa are arranged obliquely outward from the median plate; in this genus they are arranged obliquely inward, or toward the center of the corallum.

Fig. 1. Diagramatic cross-sections of *Zaphrentis dalii* E. & H., to show the characters of *Triplophyllum*. After Simpson.

[10] Chi. Y. S., Palaeontologica Sinica, B. **12** (5): 16, 1931.

Medium to large solitary corals. Corallum cornute, but varying from nearly straight to moderately curved, especially near the tip. Epitheca thin; always marked by pinnately arranged rugae and by growth annulations or swellings. Ornamentation by means of small spines is found in some species. Spines may be arranged in orderly rows, or scattered in an apparently random manner over the surface of the corallum. Calyx moderately broad and deep, but occupying less than one-third of the whole corallum. Septa in two cycles, primaries strong and well developed; secondary septa may be so rudimentary as to be practically obscured in the calicular view or may be formed so late in life as to be entirely confined to the free edge of the calyx. Primary septa reach the center of the calyx except where fused together to form the fossular wall. Fossula large and deep, extending from the margin to the center of the calyx; its position varies slightly, but is always on the concave side of the corallum. It is commonly smoothly walled by the lateral fusion of the adjacent counter-quadrant septa. Most members of this genus must have reproduced through sperms and ova, as examples of budding and fission are almost unknown.[11] Well defined scars of attachment are very rare in the majority of species.

Internal characters.—The two alar fossulae diagnostic of this genus generally are best developed in the late neanic stages, although examples are common in which the alar fossulae are clearly perceptible in the calyx. With progressive maturity the increase in the number of septa brings about a pseudo-radiality which tends to obscure or even entirely eliminate the lateral fossulae. (Pl. 10, Figs. 1, 5; Pl. 11, Fig. 8). The cardinal fossula is large and firmly walled in all but nepionic stages. It is formed from the lateral fusion of the adjacent septa, the first pair of metasepta adjacent to the cardinal septum being especially important in bounding the cardinal fossula. The cardinal septum, which in the early stages is the largest and most prominent of the septa, is usually steadily recessive, and in full maturity is rudimentary. Secondary septa are not found before the ephebic stage, and frequently are inserted much later. Tabulae are well developed throughout the entire corallum, but dissepiments are relativly few in number, and are most abundant in the older portions of the corallum.

Remarks.—The oblique inward orientation of the calcareous fibers of the septa, cited by Simpson as a generic character of *Triplophyllum,* is of very doubtful value for purposes of identification. Such orientation can be reliably detected only in sections of petrographic thinness, and it is commonly entirely obliterated in silicified specimens.

The development of alar fossulae in the nepionic or early neanic stages of a tetracoral is a normal consequence of septal insertion in accordance with Kunth's laws, and is of widespread occurrence in Palaeozoic corals. A retardation of development which preserves the alar fossulae into the ephebic and later stages is, however, a specialization which may justly be considered of generic significance. In those Triplophyllid corals which are described in

11 White, C. A., On spontaneous fission (?) in *Zaphrentis.* Amer. J. Sci. (3) **5**: 72. 1873.

the succeeding pages there is a marked variation in the extent to which the alar fossulae are preserved in the mature portions of the corallum. In each species, however, three fossulae are distinct at a late neanic or early ephebic stage, periods too late in the ontogeny to be the unmodified consequences of a common habit of septal insertion. In addition to their value as a generic index, the fossulae of *Triplophyllum* constitute a biocharacter upon which changes of palingenetic significance might readily be traced, and the genus possesses gentes suitable for such study.

Triplophyllum centralis (Milne-Edwards and Haime)

Pl. 8, Figs. 10-11; Pl. 10, Figs. 1-7.

Zaphrentis centralis Milne-Edwards and Haime, Mon. polyp. foss. terr. pal., Arch. Mus. Hist. Nat., **5**: 328, fig. 6, 1851.

Zaphrentis centralis Milne-Edwards, Hist. nat. corall., **3**: 336, 1860.

Zaphrentis centralis Worthen, Geol. Surv. Ill., **8**: 72, pl. 9, figs. 1—1a, 1890.

Zaphrentis centralis Keyes, Missouri Geol. Surv., **4**: 112, 1894.

Triplophyllum centralis Simpson, New York State Mus. Bull. **39**: 209, 1900.

Triplophyllum centralis Simpson, Univ. State New York, State Mus. Rept. 54, **3**: 209, 1902.

Description.—The original description of this species by Milne-Edwards and Haime may be translated as follows:

> Corallum a curved cone, moderately elongated, without prominent swellings, have a thin epitheca. Calyx circular; septal fossula large, central, and elongated somewhat toward the side of least curvature; 40 strong and well developed septa, alternately somewhat unequal, and appearing to fall into four groups. Height 3 centimeters; diameter of the calyx 2 centimeters.

Internal characters.—In the neanic stage (Pl. 10, Fig. 7) the cardinal septum is long and heavy, and occupies the entire length of a large fossula. Fosular wall unusually thick, owing to the reënforcement of the septa composing it with secondary deposits of stereoplasm. There are 26 well developed primary septa, those of the cardinal quadrants fusing into the fossular wall, while those of the counter quadrants extend to the alar septa. No secondary septa and but few dissepiments. The septal arrangement is radial in the counter quadrants and pinnate in the cardinal quadrants. Alar fossulae are readily discernible but not conspicuous.

The ephebic stages are illustrated by Figs 2-6 of Pl. 10. In Fig. 6 the septa have increased to about 30, and the radio-pinnate arrangement still prevails. Alar fossulae are now quite distinct. The stereoplasmic thickening of the wall of the cardinal fossula is much less pronounced, and the cardinal septum has atrophied. In Fig. 5 the primary septa number 36, and the alar fossulae are much constricted. Secondary septa now are formed, their insertion apparently having occurred simultaneously between each of the primaries. Disseptiments are few. Fig. 4 shows 44 primary septa and all the secondaries fully developed. The expansion of the calyx has increased the radial symmetry of the septa, which in the cardinal quadrants have receded from their contact with the fossular wall. A considerable open space has formed between the internal end of the cardinal fossula and the distal ends of the primary septa of the counter quadrants. Two major septa (possibly a third pair

of protosepta) play a conspicuous part in walling off the cardinal fossula. Tabulae are well developed, although not visible in the section.

Figs. 1-3 of Pl. 10 show the calyx in stages of full maturity. The septa have continued to become more radially disposed, with accompanying obliteration of the alar fossulae, which, however, are still to be distinguished in Fig. 2. With increasing growth the continued recession of the counter primary septa results in an increasing open area near the center of the corallum. Atrophy has reduced the cardinal septum to a vestige.

Remarks.—The dimensions of the holotype, as given in the original description, are those of a very small (therefore very young?) individual. The average measurement of eight specimens from the Burlington and Keokuk limestones are: mean height: 72 millimeters; mean diameter of the calyx: 33 millimeters.

Hypotypes.—31560 Walker Museum, University of Chicago; 2563 Illinois State Museum.

Horizon and locality.—Burlington limestone, Springfield, Mo., and Sulphur Springs, Mo.; Keokuk limestone, Springfield, Mo.; Chouteau limestone, Knox Co., Mo.

Triplophyllum dalii? (Milne-Edwards and Haime)

Pl. 8, Figs. 1-3; Pl. 11, Figs. 1-7.

Zaphrentis Dalii Milne-Edwards and Haime, Monog. polyp. foss. terr. pal., Arch. Mus. Nat. Hist., **5**: 329, 1851.
Cyathophyllum (fungites?) Owen, Geol. Rep. Wis., Iowa, and Minn., tab. 4, fig. 4, 1852.
Zaphrentis Dalii Milne-Edwards, Hist. nat. corall., **3**: 337, 1860.
Zaphrentis dalei Worthen, Geol. Surv. Ill., **8**: 71, pl. 10, figs. 12–12a, 1890.
Zaphrentis dalei Keyes, Missouri Geol. Surv., **4**: 113, pl. 13, fig. 12, 1894.
Triplophyllum dalei Simpson, New York State Mus. Bull. 39, **7**: 209, figs. 26–27, 1900.
Triplophyllum dalei Simpson, Univ. State New York, State Mus. Rept. 54, **3**: 209, figs. 26–27, 1902.
Triplophyllum dalei Van Tuyl, Iowa Geol. Surv., **30**: pl. 6, fig. 1, 1921-1922.

Description.—Milne-Edwards and Haime failed to figure this species; consequently it can be isolated only on the basis of their description:

> Corallum an elongated cone, curved, gently twisted, and with prominent irregular swellings. Calyx oblique, sub-circular, with a deep cavity. Septal fossula very pronounced, situated on the side of least curvature. 60 to 70 well developed septa, thin, alternately somewhat unequal; the majority extend to the center, where they are a little curved, especially those which adjoin the septal fossula. Height, 5 centimeters; diameter of the calyx 2.5 centimeters. (Translation).

Conspicuous in this description is the large number of septa, which should make the species easy to detect. Actually, however, it seems impossible to find a Mississippian Zaphrentid with as many as 60 septa, and we are left with these alternatives: either Milne-Edwards and Haime erred in counting the septa, or they based their description on a unique specimen. Fortunately the species may be provisionally isolated on the basis of other portions of their description, although Worthen remarks that the *Zaphrentis dalii* com-

monly described from the Keokuk (at the type locality) has only 36 to 42 septa, and is probably actually *Zaphrentis centralis*.

Perhaps the hope of correcting this difficulty led Keyes to emend Milne-Edward's and Haime's description of *Z. dalii*, as follows:

> Corallum simple, large, elongate-conical, more or less curved. Calyx somewhat oblique, sub-circular, deep; septal fossette well defined and located on the side of least curvature. Lamellae 40 to 60 or more in number, rather prominent, thin, somewhat irregular, and usually more or less bent toward the center. External surface rugose, and covered by short, widely scattered spines.

In addition to reducing the number of septa, Keyes supplies a further character in the form of external spines, a feature not mentioned in the original description. In the examination of more than a score of well preserved specimens the writer has discovered traces of external spines in only one, the hypotype described by Worthen. (Pl. 8, Figs. 1-2).

In his *Bibliographic Index of North American Carboniferous Invertebrates*, Weller cites *Zaphrentis spinulifera* Hall as synonymous with *Z. dalii* Milne-Edwards and Haime.[12]

Internal characters.—The early neanic stage illustrated by Pl. 11, Fig. 7, shows 26 strongly developed septa. Six of these are notably thickened; those framing the cardinal and two alar fossulae. Alar fossulae conspicuous, the pinnate arrangement of the septa of the cardinal quadrants standing in strong contrast to the radially disposed septa of the counter quadrants. Epitheca, where preserved, is thin, and a number of dissepiments is discernible. The cardinal septum extends well beyond the center of the corallum, and is heavy and considerably twisted. During later neanic developments (Pl. 11, Figs. 5-6) the principal changes center about the cardinal fossula, which becomes sharply defined and of an elongated pear shape. It is completely bisected by a long, straight, and rather thin cardinal septum. In Fig. 5 the septa have increased to 36, and progress toward radial symmetry is apparent in their disposition. This is specially true of the cardinal quadrants, where the septa have lost much of their pinnate arrangement in spite of their coalescence about the cardinal fossula.

Pl. 11, Fig. 4, exhibits an early ephebic stage. The septa number 40; the attendant expansion of the corallum has greatly lengthened the cardinal fossula, while the insertion of new septa has resulted in a compression of the alar fossulae, which are now somewhat obscured. Bridging the cardinal fossula at intervals are the fused ends of several pairs of adjacent septa, the conjunction of which marked the boundary of this opening during previous stages of growth. The cardinal septum has begun to atrophy, and occupies less than one-half the length of its fossula. Tabulae are more numerous than in any of the previous stages, and the section shows a marked increase in the number of dissepiments. There is no suggestion of secondary septa.

Pl. 11, Figs. 1-3 show successively later stages of ephebic growth. The maximum number of septa achieved is 46, and those of the cardinal quadrants have become elongated to keep pace with the recession of the septa of the

12 Weller, S., Bull. U. S. G. S. No. 153, p. 647, 1898.

counter quadrants. The cardinal fossula has also increased in length proportionally as the calyx expands. Fig. 1 reproduces a section taken immediately below the base of the calyx of an adult form, and it is significant that it reveals no suggestion of the formation of secondary septa. In *Triplophyllum dalii* the development of secondary septa takes place at a late stage of adult life, and their occurrence is commonly limited to the free edge of the corallum surrounding the calyx proper. Once formed, however, they may expand rapidly, and examples are common in which the intercepts of the secondary septa on the upper margin of the corallum are as strong as those of the much older primaries.

Remarks.—The close morphological similarity between *Triplophyllum centralis* and *T. dalii* makes it perhaps desirable that the two forms be compared, and some stress laid upon the differentiating characteristics. Externally these species are alike in being large forms with smooth coralla and lightly imprinted rugae. The epitheca of *T. dalii* is wrinkled and annulated, however, and may show short, scattered spines occasionally somewhat linear in arrangement, whereas the epitheca of *T. centralis* is relatively smooth and is never spinose. Within the calyx, the septa of *T. dalii* are thin, and recurve somewhat before their termination. They remain sharply distinct to their merger in the center of the corallum. The septa of *T. centralis,* as seen in calicular view, are broader and heavier, and disappear before reaching the centr of the calyx, leaving a smooth tabulate area about the cardinal fossula.

In section *Triplophyllum dalii* is distinguished by its long, narrow fossula, frequently showing a bulbous expansion at its inner end, and by the absence of secondary septa in the ephebic and earlier stages. In mature sections the septa of the cardinal quadrants in *T. dalii* remain more closely parallel to the cardinal fossula than do those of *T. centralis;* this phenomenon is produced in part, at least, by the tendency of the former to elongate as the septa of the counter quadrants recede, whereas in *T. centralis* the recession of the counter-quadrant septa produces an open space near the center of the corallum. The septa of *T. dalii* generally have a greater tendency to recurve about the cardinal fossula than do those of *T. centralis,* but this habit is hardly sufficiently pronounced to be considered diagnostic.

Hypotypes.—31546 Walker Museum, University of Chicago; 2556 Illinois State Museum.

Horizon and locality.—Keokuk limestone. Warsaw, Ill., and Crawfordsville, Ind.; Burlington limestone, Springfield, Mo., and Jersey Co., Ill.; Keokuk limestone, Keokuk, Iowa.

Triplophyllum cliffordanum (Milne-Edwards and Haime)

Pl. 8, Figs. 4-5; Pl. 11, Figs. 8-16.

Zaphrentis cliffordana Milne-Edwards and Haime, Monog. polyp. foss. terr. pal., Arch. Mus. Nat. Hist., **5**: 329, pl. 3, fig. 5, 1851.
Zaphrentis cliffordana Milne-Edwards, Hist. nat. corall., **3**: 337, 1860.
Zaphrentis cliffordana Worthen, Geol. Surv. Ill., **8**: 75, pl. 10, figs. 1–1b, 1890.
Zaphrentis cliffordana Whitfield, Ann. N. Y. Acad. Sci., **5**: 576, pl. 13, figs. 1–3, 1891.
Zaphrentis cliffordana Whitfield, Geol. Surv. Ohio, **7**: 465, pl. 9, figs. 1–3, 1895.

Zaphrentis cliffordana Grabau and Shimer, N. Amer. Index Foss., **1**: 58, 1909.
Zaphrentis cliffordana Weller, Bull. Geol. Soc. Amer., **20**: 272, pl. 10, figs. 18–19, 1909.
Zaphrentis cliffordana Butts, Geol. Alabama: 170, pl. 54, fig. 7, 1926.

The original description of this species, by Milne-Edwards and Haime, covers the external characters in considerable detail:

> Corallum a curved cone, elongated, without protuberant swellings; epitheca thin, allowing a perception of the serrated ribs (which are) equal, plane, and fairly straight. Calyx circular, quite deep; septal fossula rather large, oblong, situated on the side of least curvature; 32 or 36 sub-equal septa, strong, slightly thickened toward the outside, thinning toward the inside, extending for the most part to the center of the uppermost tabula, upon which they are very slightly curved, and not re-elevated. Their free edge appears obliquely cut. One distinguishes among these septa an equal number of rudimentary septa. Height 3 or 4 centimeters, diameter of the calyx from 1½ to 2 centimeters. (Translation).

To the foregoing description may be appended that given by Weller for the *Zaphrentis cliffordana* of the Fern Glen beds:

> Corallum simple, curved, horn-shaped, subcircular in cross-section, expanding somewhat regularly, the sides diverging from the apex at an angle of 35 to 45 degrees, subcarinate along the convex side toward the apex; the axis of the corallum describes a curve which approaches the quadrant of a circle, but which is somewhat more rapidly curved toward the apex. Surface marked by regular annular wrinkles of moderate strength and by almost obsolete longitudinal ribs which correspond in position with septa. Calyx of moderate depth, with a broad base, the fossula of moderate size and depth adjacent to the shorter side of the corallum. Septa in a large individual with a calyx diameter of 20 millimeters, 35 in number without alternating smaller ones; another individual with a calyx diameter of 13 millimeters, has stronger septa with an equal number of small, low septal ridges alternating with them. The septa do not reach the center of the calyx, but leave a smooth clear space in the bottom.
>
> The dimensions of two individuals are: Length of the longer side of the corallum, 44 and 38 millimeters; length of the shorter side of the corallum, 19 millimeters and 19 millimeters; diameter of calyx, 20 millimeters and 13 millimeters.

Internal characters.—Fig. 16 of Pl. 11 illustrates a neanic stage of *Triplophyllum cliffordanum*. In it the septa are seen in the process of insertion in coalesced groups of unequal development. The cardinal septum is strong and extends to the center of the corallum; in addition there appear to be four groups of primary septa of nearly equal development, and four groups seemingly later in origin. There is no suggestion of alar fossulae, and the cardinal fossula can be located only from the position of the cardinal septum. The epitheca at this stage appears moderately thick, but this is due in part, at least, to the obscuring effects of the silicification of the specimen. There are very few dissepiments. Pl. 11, Fig. 15, shows an early ephebic stage. The septa number 21, and are thicgk and marginally retracted, especially in the counter quadrants. Their disposition exhibits a pronounced radial symmetry. The cardinal septum is abnormally shortened because of poor preservation. The cardinal lateral primaries are in the process of elongation and fusion to form the cardinal fossula. Alar pseudo-fossulae appear to exist, but have not been well preserved. Fig. 14 shows a more advanced ephebic stage, and has suffered some distortion from infiltering silica solutions, which have produced a zonal banding in the open area left by the general marginal retraction of the

septa. The presence of the siliceous replacement material suggests that the center of the corallum was originally filled with stereoplasm, deposited in a kidney-shaped mass about the inner end of the cardinal fossula. Such a conclusion is borne out by the study of other sections. The septa number 32, and have retained the general straightness of the preceding section, but are somewhat less radial in arrangement. A more striking change is the apparent fission of the septa into two component leaflets, a condition especially noticeable in those of the counter quadrants. This appearance seems primarily caused by differential replacement of the original calcareous material. Structureless stereoplasm is more susceptible to siliceous replacement than are organically oriented calcite crystals; there is thus evidence that the septum proper is but a slender blade, thickly covered with stereoplasm.[13] Fig. 13 represents a stage of full maturity. The septa number 36, although the cardinal septum is practically atrophied; an indeterminate number of weakly developed secondary septa is also present. The major septa have failed to elongate in proportion to the expansion of the calyx, and in consequence have undergone a general marginal retraction; they have retained the straightness of the earlier stages, but are relatively broader, and their distal ends are generally free and markedly thickened. Fig. 12 shows a mature stage in a different specimen. The section is noteworthy for the good development of the alar fossulae, the characteristic curved cardinal fossula, with bulbous inner termination , and the absence of secondary septa. The primary septa number 20, and dissepiments are few. Tabulae are well developed throughout the corallum.

Hypotypes.—4704 Walker Museum, Univ. of Chicago.

Horizon and locality.—Fern Glen shale, Kimmswick, Mo., and Sulphur Springs, Mo.; Kinderhook, Monroe Co., and Jersey Co., Ill.

Triplophyllum cliffordanum var. **hespere** var. nov.

Pl. 8, Fig. 6; Pl. 18, Figs. 9-11.

Description.—In external form this variety differs but little from the typical *Triplophyllum cliffordanum*. The only character of note in this regard is a somewhat more rapid bulging of the corallum after the neanic stage, giving the upper part of the cup a rather swollen aspect, and producing a larger calicular diameter than would be found in a typical *T. cliffordanum* of equal length. Variety *hespere* also achieves a larger size than is known for the type form. A mature specimen measured 32 millimeters calicular diameter, 47 millimeters along the concave side and 60 millimeters along the convex side. This specimen possesses 36 major septa, alternating with an equal number of weakly developed secondaries.

The internal characters of the variety are shown in Figs. 8-11 of Pl. 11. The general septal development closely parallels that of *T. cliffordanum*, but the septa assume a decidedly radial symmetry at a very early stage, and the alar fossulae never find a clear expression. It is noticeable in Fig. 10 that the

13 Compare Frech, F., Zeitschr. Deutsch. Geolog. Gesell., **37**:928-934, 1885.

early quadripartite grouping of the septa is retained into a relatively late period of development, and the pronounced thickening of the distal ends of the septa during the ephebic stage is conspicuous in Fig. 9. The mature section of Fig. 8 is noteworthy for the marked radiality of the septa, and for the comparatively small number of septa possessed at so advanced a stage. The septa are thick and strong, with very wide interspaces, and show a composition similar to those of the type form. The alar fossulae are entirely lacking.

In general characters the variety is such as might be derived from a typical *T. cliffordanum* in consequence of growth to a larger size, with a retarded and accentuated development of the endothecal apparatus through each successive period of growth. The mature stages of *T. cliffordanum hespere* are strikingly similar to the early stages of *Bradyphyllum bellicostatum* Grabau,[14] the principal apparent difference being the development of tabulae in the former.

The specimens upon which the variety is founded occur in the Mississippian (Kinderhook) formation of Lake Valley, New Mexico, and are numbered 31570 of the Gurley collection in Walker Museum, the University of Chicago.

Triplophyllum welleri nom. nov.

Pl. 8, Fig. 9; Pl. 13, Figs. 21-25.

Zaphrentis cliffordana? Worthen, Geol. Surv. Ill., **8**, pl. 10, fig. 1b (not fig. 1), 1890.
Zaphrentis wortheni Weller, Bull. Geol. Soc. Amer., **20**:273-274, pl. 10, figs. 20, 21, 1909.

Zaphrentis wortheni Weller 1909 is preoccupied by *Zaphrentis wortheni Nicholson* 1875[15], hence Weller's species is here renamed *welleri*.

Description.—Weller identifies *Triplophyllum wortheni* as follows:

> Corallum horn shaped, the sides diverging at an angle of about 30 degrees. Surface rather smooth, marked by more or less infrequent annular wrinkles which are usually of small size. Rim of the calyx oblique; the calyx deep, contracted below, with a fossula of moderate depth and width toward the shorter, concave side of the corallum; the major septa 25 to 30 in number, their inner extremities extending toward the center of the floor of the calyx, but leaving a small central clear area; between the major septa and alternating with them are an equal number of much lower septa which are sometimes scarcely more than septal ridges.
>
> The dimensions of two individuals are: Length of corallum on convex side, 54 millimeters and 40 millimeters; length of corallum on concave side, 30 millimeters and 17 millimeters; diameter of calyx at rim, 21 millimeters and 18 millimeters. . . . This species includes the straighter individual figured by Worthen under the name *Zaphrentis cliffordana*. It differs from the coral to which that name is here restricted in its much straighter and more elongate form, in the smaller angle of divergence of the sides of the corallum, and in the more oblique position of the calicinal rim.

Internal characters.—Figs. 21 to 25 of Pl. 13 illustrate sections of *T. welleri* from late youth to maturity. In general the endothecal structure of these later ontogenetic stages is identical with that of the Triplophyllid corals already reviewed. The radio-pinnate orientation of the major septa in the

14 Grabau, A. W., Pal. Sinica, B, **2**(2):37, pl. 2, figs. 11 a-e, 1928.

15 Nicholson, H. A., Geol. of Ohio, **2**:235, 1875.

earlier ephebic stages, with subsequent regular increase toward radial symmetry, the progressive atrophication of the cardinal septum, the accentuation of the alar fossulae in the younger portions of the corallum, and the relative paucity of dissepiments are all characters persistent throughout the genus. Significant for the identification of the species, however, are the rather thin and slightly wavering septa, which extend to the center of the corallum and interfuse. Their conjunction may give rise to a dense mass in the center which is roughly crescentiform about the inner end of the cardinal fossula. The formation of secondary septa in an early ephebic stage is sufficient to differentiate this species from *T. cliffordanum*. The shape of the cardinal fossula is not diagnostic, as its curvature and bulbous inner termination strongly suggests that of *T. cliffordanum*.

Remarks.—The similarity of *T. welleri* and *T. cliffordanum* both in appearance and internal structure indicates that they are closely related phylogenetically. They occur together in the Kinderhook strata, and it is not known that one has an earlier range than the other. In the ontogeny of *T. cliffordanum* there is an ephebic stage in which the septa are thick and shortened, and the cardinal fossula weakly developed; such a stage is not present at a comparable period in *T. welleri*. If the shape of the cardinal fossula may be trusted as a biocharacter, its expression in adult sections of *T. cliffordanum* is found repeated in early ephebic sections of *T. welleri*, and thus indicates the latter as the younger species. An alternative inference is the successive derivation of both from a common ancestor which must have been very close to *T. dalii*.

Cotypes.—4705 Walker Museum, University of Chicago

Horizon and locality.—Kinderhook (Fern Glen) Kimmswick, Mo.

Triplophyllum spinulosum (Milne-Edwards and Haime)

Pl. 9, Figs. 1-5; Pl. 12. Figs. 1-11.

Zaphrentis spinulosa Milne-Edwards and Haime. Monog. polyp. foss. terr. pal., Archiv. Mus. Hist. Nat., **5**:334, pl. 5, figs. 7. 7a. 1851.
Zaphrentis spinulifera Hall, Geol. Iowa. **1**(2):650, pl. 22. figs. 1a-b, 1858.
Zaphrentis spinulosa Milne-Edwards, Hist. Nat. Corr., **3**:340. 1860.
Zaphrentis spinulifera White, Am. Jour. Sci. **5**(3):72, 1873.
Zaphrentis spinulosa Worthen, Geol. Surv. Ill., **8**:73, pl. 10. figs. 6-6a, 1890.
Zaphrentis chesterensis Worthen, Geol. Surv. Ill., **8**:73, pl. 9, figs. 3-3a, 1890.
Zaphrentis pellaensis Worthen, Geol. Surv. Ill., **8**:74, pl. 9, figs. 6-6a; pl. 10, figs. 11-11a, 1890.
Zaphrentis spergenensis Worthen, Geol. Surv. Ill., **8**:77. pl. 10, figs. 8-8a, 1890.
Zaphrentis spergenensis Keyes, Missouri Geol. Surv., **4**(2):115, 1894.
Zaphrentis spinulosa? Rominger, Geol. Surv. Mich., **3**(2):152, pl. 54, 5 figs., 1876.
Hapsiphyllum spinulosum Brown, Ann. N. Y. Acad. Sci., **19**:85, figs. 15-16, 1909.
Zaphrentis spinulosa Butts, Geol. Alabama, Sp. Rept. **14**, Ala. Geol. Surv., p. 198, pl. 65, fig. 5, 1926.

Description.—Milne-Edwards and Haime described *Zaphrentis spinulosa* as follows.

Corallum turbinate, moderately elongated, weakly curved and lightly twisted, presenting some irregular swellings and a thin epitheca which upon the parts neighboring

the base forms small conical and sub-spiniform points. Calyx circular, moderately deep; septal fossula moderately developed, situated near the wall, but having a variable position with respect to the curvature; 30 septa, rather thin, very faintly curved near the septal fossula; an equal number of rudimentary septa. Height about 3 centimeters; diameter of the calyx from 1.5 to 2 centimenters. (Translation).

Individuals of this species attain a considerably larger size than is indicated in the preceding description. A large *Triplophyllum spinulosum* from the Paint Creek (Chester) formation measured 60 millimeters along the convex side, 53.7 millimeters along the concave side, and 32.9 millimeters in average calicular diameter. This specimen possesses 42 major septa and an equal number of secondaries. Forms of a similar size are not at all rare.

The numerous small spines to which the species owes its name are arranged upon the epitheca in fairly straight horizontal bands. In each row there are several spines within the space of a centimeter, whereas the vertical distance between succeeding bands is three or four times as great, and increases toward the margin of the calyx. Contrary to the impression gained from Milne-Edwards and Haime's description, the spines are not confined to the vicinity of the base, but may be found on the very rim of the calyx, even in mature specimens. The shape of the corallum varies from nearly straight to gently cornute. The diameter of the calyx increases rapidly after maturity, and forms of large size are decidedly top-shaped.

The species *spinulosum* embraces several distinct varieties, and almost every shade of transition between these. Externally there are no constant characters which distinguish one variety from another, and they can be separated *inter-se* only by studying the internal structure. It would be necessary to section the holotype before the internal characters proper to the species *spinulosum* could be delineated with precision. In the absence of opportunity for this, it is deemed advisable to describe here the two extremes of the observed mutations as variety α and variety β. The septal pattern possessed by the majority of the specimens sectioned is approximately intermediate between α and β; this pattern is shown in Fig. 2.

Hypotypes.—25192 Walker Museum, Univ. of Chicago; 2559 Illinois State Museum.

Horizon and localities.—Kinderhook to Upper Chester, Illinois, Missouri, Iowa, and Arkansas.

Fig. 2. Camera lucida drawings showing the arrangement of the septa as observed in the majority of specimens of *Triplophyllum spinulosum*.

Triplophyllum spinulosum α

Internal characters.—During the neanic period *T. spinulosum α* exhibits a fairly uniform radial distribution of the septa (Pl. 12, Fig. 10) in consequence of the failure of the protosepta to be differentiated from the other primaries, and from the lack of distinct fossular development. At this stage it is frequently necessary to study the exterior of the calyx to determine the position of the cardinal and alar septa. Tabulae and dissepiments are already well developed in the neanic stage.

As the ephebic period is approached, the septa assume the pattern characterizing other members of the genus *Triplophyllum* (Pl. 12, Figs. 3, 4). The cardinal septum is unusual among Triplophyllid corals in that it increases in size during the ephebic period. Similarly, the cardinal fossula is better developed in the sections taken from a stage of early maturity (Pl. 12, Figs. 1, 2). The alar fossulae are formed early in the ephebic stage, and retain their development throughout the remainder of the corallum, being frequently most distinct in the calyx itself (Pl. 9, Fig. 5). With progressive growth the cardinal septum atrophies, and is rarely perceptible in the calyx of an adult.

During the early stages of *T. spinulosum α* the septa are thin and considerably twisted as they approach the center of the corallum. With increase in age they become straighter, heavier, and taper from a proximal thickening.

The vertical sections of Figs. 5 and 11, Pl. 12, show the nearly uniform development of tabulae throughout the corallum.

Triplophyllum spinulosum β

Internal characters.—This rarer variety of *T. spinulosum* is shown in Figs. 6-9 of Pl. 16. The neanic stages are essentially similar to those of the first described variety, the divergence of the two becoming marked in the ephebic stages. *T. spinulosum β* differs from *α* chiefly in the configuration of the septa, which in the former are very broad, blade-shaped in cross-section, and taper gradually to a point. The width of the septa constricts the interseptal loculi. The septa converge at the center of the corallum, where their ends twist slightly together. In youthful stages the cardinal septum is slightly longer than the radius of the corallum; it becomes recessive with maturity. In the older portions of the corallum the broad septa crowd the alar fossulae out of existence, but in the early ephebic stages, before the septa have achieved their full width, the alar fossulae are clearly visible. Tabulae are less numerous than in variety *α* and dissepiments are of comparatively rare occurrence. As may be seen in Fig. 6, a section cut immediately below the calyx, the thickness of the septa is not conspicuous in the calyx itself. Secondary septa develop at a late stage, and are confined to the calicular wall.

Remarks.—The examination of hundreds of specimens of *T. spinulosum* shows that *Zaphrentis spinulifera* Hall is synonymous with *Triplophyllum spinulosum* (E. & H.). Hall's description of his species is:

> Coral in the form of a reversed cone, curved. Calyx slightly oblique, circular or sub-circular, the cavity deep; septal fossette strongly marked, situated on the inner side

of the curvature. Radiating lamellae strongly defined, somewhat irregularly curved, numbering at the margin from forty-two to fifty, and uniting in fascicles of two, three, four or more before reaching the center; outer walls of the calyx thin at the upper margins, becoming very thick and strong below. Externally somewhat rugose, and often swelling abruptly at intervals; the stages of growth marked by somewhat regular rows of nodes or short spines.

The exact systematic position of *Z. spinulifera* has long been in dispute. Worthen concluded that it must be identical with *Z. dalii* E. & H., and remarks:

> This description (of *Z. dalii*) corresponds well with the form described subsequently as *Z. spinulifera*, the principal difference being in the larger number of lamellae in E. & H.'s specimen. This character, however, is a variable one, and as there is no other form known from that locality that has even as many as fifty lamellae, it becomes almost certain that their specimen was specifically identical with that subsequently described as *Z. spinulifera*.[16]

Worthen seems to have reached his conclusion chiefly because of his inability to attribute as many as 42 septa to *Triplophyllum spinulosum;* and a careful examination of his hypotype for *Z. spinulifera* (Pl. 8, Fig. 12) shows that he was further deceived through identifying a large *T. spinulosum* as *T. dalii*. It has already been remarked, however, that examples of *T. spinulosum* possessing 42 or more septa are fairly common in numerous Chester horizons, and also at Hall's type locality at Warsaw, Illinois, whence came Worthen's hypotype. In every external detail these large forms are strikingly similar to Hall's figure of *Z. spinulifera,* and there seems, therefore, to be no tangible reason for maintaining the specific distinction of the latter. A similar conclusion was reached by Keyes, who remarks:

> Hall's form, *Z. spinulifera*, originally described from Warsaw, Illinois, is without doubt identical with the species under consideration *(Zaphrentis spinulosa* E. & H.), and is so regarded here.[17]

Keyes did not cite the evidence which led him to this conclusion.

Certain other of the Mississippian species described by Worthen in volume 8 of the Geology of Illinois are here considered as synonymous with *T. spinulosum: Zaphrentis chesterensis* is described by Worthen as follows:

> Corallum elongated, moderately curved, gradually and regularly tapering; calyx circular, not deep, fossette deep, and situated on the side of shortest curvature. Lamellae in four divisions, the two on either side of the fossette to the number of seven or eight coalesce before reaching the bottom of the calyx. On each side of the strong septum opposite the fossette, there are twelve or thirteen lamellae that extend singly to the bottom of the cup. Surface slightly rugose, with traces of short spines scattered irregularly over it.
>
> This is a variety of *Z. spinulosa*, E. & H., but may readily be distinguished by its more elongated and symmetrically tapering form, and the greater number of lamellae.

Worthen's holotype has been carefully studied, and possesses no character justifying the separation of *Z. chesterensis* as a species distinct from *T. spinulosum.* (Pl. 9, Fig. 2.). The above description of the septal apparatus of *Z.*

16 Worthen, A. H., Geology of Illinois, 8:72, 1890.
17 Keyes, C., Missouri Geol. Surv., 4:114, 1894.

chesterensis is equally applicable to *T. spinulosum,* differing from the arrangement in that species no more than its individual members might differ from each other. The characters cited as identifying *Z. chesterensis,* namely, its large number of septa and its elongated and symmetrically tapering form, do not, as revealed in the holotype, form the basis for a new species. They are repeated among the members of the type species with sufficient frequency, however, to constitute a recognizable variety.

The conclusions stated above for *Z. chesterensis* Worthen apply with equal force to *Z. pellaensis* Worthen. The description of this species is:

> Corallum turbinate, regularly curved, height of an average specimen 1⅜ in., diameter of calyx about ¾ in., depth of cup ⅜ in.; sides descending abruptly, the lamellae on each side of the fossette to the number of four or six coalescing, while the others extend singly nearly to the center of the cup. Fossette narrow and situated obliquely to the curvature of the corallum. Whole number of principal lamellae 32 to 36 with about the same number in the secondary series. Surface moderately rugose, and often marked by a few short scattering spines that are usually restricted to the lower portion of the corallum.
>
> This form is closely related to *Z. spinulosa* E. & H. from the Chester beds, but is usually shorter in proportion to its diameter, and coming from a different geological horizon it is entitled to be considered as a distinct variety.

An examination of the cotypes (Pl. 9, Figs. 3-4) fails to reveal any characters distinguishing *Z. pellaensis* from *T. spinulosum.* The internal structure of this species is that of *T. spinulosum;* its proportions, which are duplicated by large numbers of individuals of *T. spinulosum,* would permit its retention as a variety of that species. Stratigraphic position can scarcely be considered a character of specific worth, and Worthen's use of it as such in this case is in disregard of the long range of *T. spinulosum.* It is also true that the attributes of form which distinguish Worthen's species are not confined solely to corals from the Pella beds, but are found in individuals from a variety of horizons.

Zaphrentis spergenensis Worthen is also here held to be synonymous with *Triplophyllum spinulosum* (E. & H.). Although the holotype of this species has been lost, at least temporarily, Worthen's figures and description indicate that *Z. spergenensis* is certainly a *Triplophyllum,* and almost equally certainly a young individual of *T. spinulosum.*

Triplophyllum illinoisense (Worthen)

Pl. 8, Figs. 7-8.

Zaphrentis illinoisensis Worthen, Geol. Surv. Ill., 8:77, pl. 9, figs. 4-4a, 1890.
Zaphrentis illinoisensis Keyes, Missouri Geol. Surv., 4:112, 1894.

Description.—Worthen's original description is:

> Corallum very broadly turbinate, cup oblique, surface marked by several transverse undulating ridges and numerous longitudinal striae. Septal fossette deep and situated on the side of least curvature; lateral fossettes narrower but distinct, separating the lamellae into three well marked divisions, the two on either side of the septal fossette consist of ten or eleven each, making thirty-eight to forty primary lamellae in the entire cup.

This species was evidently sessile, and was attached near the lower extremity to some cylindrical body, the scar of attachment being visible on nearly all the individuals seen.

Length of a large individual 2⅞ in., breadth of cup 2 and 1-16 in.; depth of same about 1 in.

Remarks.—The unusually broad, deep calyx of *T. illinoisensis* excellently illustrates the characters of the genus *Triplophyllum*. The cardinal fossula is of exceptional width and depth, and extends slightly beyond the center of the calyx; it expands noticeably toward its internal termination. The two alar fossulae, likewise strongly developed, merge with the cardinal fossula at the center of the calyx, joining it at angles of about 60 degrees. The juncture of these three produces an open area at the center of the calyx of such size as to greatly increase the apparent calicular depth.

The primary septa are exceptionally thick, but the calyx flares out so broadly that their proximal ends are not crowded, and the interseptal spaces are much wider than is common in a form possessing as many as 20 septa. This latter phenomenon has an unusual effect upon the rugae or external striations upon the corallum, giving them the appearance of double lines ruled at intervals upon the epitheca, rather than the customary unilinear appearance. The cardinal septum is completely aborted in the post-neanic stages.

Triplophyllum illinoisensis is closely related to *T. centralis;* the two differ chiefly in those features attendant upon the much greater expansion of the calyx in the former.

Holotype.—2562, Illinois State Museum, Springfield, Ill.

Horizon and localities.—Keokuk limestone, Warsaw, Ill., and near Plymouth, Hancock Co., Ill.; Wayland, Clark Co., Mo.; Keokuk and Bonaparte, Iowa.

Genus **Homalophyllum** Simpson emend. Grove

Homalophyllum Simpson, New York State Mus. Bull. **39**, **7**:221, 1900.
Homalophyllum O'Connell, Annals New York Acad. Sci., **23**:192, 1914.

Genotype—Zaphrentis ungula Rominger, Geol. Surv. Mich., **3:** 181, 1876. Onondaga limestone.

Example.—Zaphrentis herzeri Hall, Fossil corals, Niagara and Upper Held. Groups: 35, 1882.

Description.—Corallum cornute, but asymmetrically flattened on the cardinal (convex) side. Calyx sub-oval to round. Primary and secondary septa well developed, the former reaching to the center of the calyx, where they may recurve slightly upward. Cardinal fossula moderately large, extending to the center of the calyx on the convex side. Tabulae and dissepiments occur, but are not conspicuously developed. The members of this genus show no evidence of an operculum at any stage of development.

Simpson's original description of this genus is:

The above species *(Zaphrentis ungula* and *Z. herzeri)* have a decided characteristic in that they are flattened on the side of greatest curvature; for some distance from the apex they are concave; calyx oval, with one side straighter than the opposite side. The form of the corallum is similar to that of *Calceola.* They make a natural group which differs from *Zaphrentis,* and should be removed from that genus.

Homalophyllum calceolum (White and Whitfield)

Pl. 9, Figs. 20-24; Pl. 13, Figs. 1-6.

Lophophyllum calceola White and Whitfield, Proc. Bost. Soc. Nat. Hist. **8**:305, 1862.
Zaphrentis calceola White, Cont. Invert. Paleon., No. 8, in, Hayden, U.S.G.S. Surv. Terr. Wyoming and Idaho; 156, pl. 39, figs. 6a-d, 1880.
Zaphrentis calceola Rowley, Am. Geol. **3**:275, 1889.
Zaphrentis calceola Keyes, Missouri Geol. Surv., **4**(1):110, 1894.

Description.—In their original description of this species, in 1862, White and Whitfield assigned it to the genus *Lophophyllum*. Later perceiving this to be an error, White redescribed it in 1880, placing it in the genus *Zaphrentis*. His revised description is:

> Corallum small, subturbinate, more or less curved, moderately but irregularly expanding from the base or apex upwards, flattened on the outer side of the curvature, especially at the lower portion, but elsewhere somewhat regularly rounded; apex small, pointed; exterior surface rugose from unequal growth; calyx moderately deep; fossette situated subcentrally, but extending towards the side of the convex curve of the corallum; principal rays about thirty; secondary rays about equal in number with the principal ones, but they are usually very small and inconspicuous.
>
> Extreme length of an average example, 18 millimeters; diameter of calyx, about 9 millimeters.

As originally described, this form differed from its all too numerous fellows in the genus *Zaphrentis* chiefly in the marked flattening of the convex side. An inspection of the calyx reveals yet further departures from the characters attributed to the genus *Zaphrentis*, though the external asymmetry of the corallum first commands attention. The flattening of the convex side thus indicated is greatest at the tip, and becomes gradually less pronounced with growth, so that a mature calyx may present a cross-section which is essentially circular. The corallum of *Homalophyllum calceolum* is also marked externally by a series of alternating constrictions and swellings, of unusual regularity, which begin a short way above the tip and continue to the rim of the calyx. These annulations, which may possibly be indicative of periodic rejuvenation, are noteworthy for the marked parallelism of each of the constricting bands.

The calyx of *H. calecolum* is moderately deep, and in a mature specimen there are from 30 to 36 well developed major septa and an equal number of short secondaries. The septa are nearly radially disposed, and the primaries extend well toward the center of the calyx, but before reaching the center they recurve slightly upward and coalesce. As a result the center of the calyx is composed of the fused ends of the septa, apparently reënforced by deposits of stereoplasm, thus forming a protuberance raised somewhat above the remainder of the calicular floor. The structure resulting is in many respects suggestive of an incipient columella, but at no stage of development is it sufficiently marked to be termed columelloid. As can be seen in the serial sections reproduced in Figs. 1-5 of Pl. 13, *H. calceolum* does not deviate markedly from the general pattern of the tetracorals in the appearance of its calyx. In addition to the arrangement of the septa already described, there exists a well-developed cardinal fossula which preserves its strength through

all but the earliest stages of the corallum. The cardinal septum, when first visible, extends the full length of its fossula, and subsequently undergoes the progressive atrophication observable in many of the *Zaphrentidae*. Tabulae and dissepiments are not perceptible in any of the serial sections, but their absence is due to poor preservation.

From the orientation afforded by a study of the septal arrangement, it is seen that the flattened side of the corallum is the cardinal side.

When, however, the tip of the corallum, which is characterized by the maximum degree of external asymmetry, is examined in section, the internal structure is found to differ greatly from that of the later and more cylindrical portions. (Pl. 13, Fig. 6). The septa of this neanic stage are short and chaotic in arrangement. Of the primary septa, only the cardinal septum is outstanding; there is little suggestion of a fossula, and the entire center of the corallum is open.

Hypotypes.—31584 Walker Museum, University of Chicago.

Horizon and Range.—Chouteau limestone, Sedalia, Missouri.

Relationships of Homalophyllum calceolum.—In the morphology of *H. calceolum* there are two dominant trends: A columella-like fusion of the major septa in the center of the calyx; and a tendency to flatten the convex side of the corallum. The first of these is best expressed in the more mature portions of the individual, whereas the second is pronounced only in the earliest stages. The determination of the generic position of the species rests upon the evaluation of both of these factors, and the study of their closest affinities among other tetracorals.

As has been noted, the first of these trends, that of a columella-like coalescence of the septa, is weakly developed. The structure produced is never strongly demarcated, and comes into existence only in the maturity of the individual. If this were a vestigal heritage, in the slow process of atrophication, its development should at least remain uniform throughout the corallum, or rather become somewhat feebler with increase in the age of the individual. The fact that the reverse condition prevails seems to indicate that this is a morphological unit in the process of formation—a structure whose fulfillment is to be sought in the progeny, and not the ancestry, of the species under observation. It has often been noted that the later Carboniferous corals are characterized by the widspread development of columellae, and it may be that the structure here described is an early forshadowing of such a trend. There is, however, considerable opposition to the unqualified adoption of such a view. A tendency of the septa to recurve upwards into a columelloid structure is noted by Milne-Edwards and Haime in their description of the genus *Cyathophyllum:*

> Cloisons bien developpées et s'étendant jusqu'au centre du calice, ou èlles sont légèrment courbées et relevées de manière a produire quelquefois l'apparence d'une columelle rudimentaire. (Milne-Edwards, Histoire Naturelle des Coralliaires, 3:364.)

A similar septal structure is noted by Hall in a number of the species of *Zaphrentis* which he describes from the Devonian Falls of the Ohio.[18]

18 Hall, J., 12th Ann. Rept. Ind. Dept. Geol. Nat. Hist. pp. 285-297, 1882.

In consequence of these several possible interpretations, this peculiarity of the septa can scarcely serve as an index to the generic position of *H. calceolum,* and seems rather a feature of homeomorphy, since a somewhat similar structure is remarked for the primitive genus *Streptelasma* Hall. It is, therefore, to the trend manifested in the flattened cardinal side that we must turn as an initial means of isolating the forms congeneric with *H. calceolum.*

The list of North American corals exhibiting a flattening of one side is not lengthy, but when it is combined with that of similar forms known from other parts of the world, a very considerable number of species is embraced. Our terminology does not provide us with a means of designating this group as a whole, yet there is a definite need of avoiding the clumsy redescription of these corals each time it is desired to refer to them collectively. This need has been recognized by the Germans, who indicate them as "*Pantoffel* (slipper) corals." If only for phonetic reasons, this word is scarcely suitable for adoption into English terminology, and in its place the term "calceoloid corals" (Latin *calceolus*—a little shoe) is here proposed. This designation has the dual advantage of being based on the most conspicuous morphological feature of the group, i. e., their slipper-like shape, and of suggesting their most typical representative, the familiar genus *Calceola* Lamarck.

Among the North American representatives of the calceoloid corals are the following genera and species:

Calceola attenuata Lyon—(Niagaran, Kentucky, Tenn.)
C. coxii Lyon—(Niagaran, Tenn.)
C. cornicula Lyon—(Niagaran, Tenn.)
C. tennesseensis Roemer—(Niagaran, Kentucky, Tenn.)
Halophragma calceoloides Lds.—(Upper West Union Fm., Ohio)
Cyathophyllum exiguum Billings—(Onondagan, Ohio, Ontario)
Homalophyllum herzeri Hall—(Onondagan, Ohio)
H. ungulum Rominger—(Onondagan, Ohio, Miss. valley)
H. calceolum Wh. and Whit.—(Chouteau Is., Indiana, Missouri)
Zaphrentis compressa Rominger—(Onondagan, Ohio).

Even a cursory inspection of the superficial characteristics of this assemblage permits it to be separated into several constituent groups: *Calceola tennesseensis, C. cornicula, C. coxii,* and *C. attenuata* all possess opercula, and in each of these species the counter side is the flattened side.[19] Their proper position in the genus *Calceola* is therefore apparent.

Halophragma calceoloides is flattened on the cardinal side, and does not possess an operculum at least in mature stages. This coral was first described by Lindström, who attributed to it an origin indepenedent of the *Calceolidae.* Its peculiar form has been interpreted by Richter, who says of it:[20]

> This species builds itself a sharply bounded *Calceola*-like corallum, but in about the second half of its growth bends itself upwards and takes on a circular cross-section . . . There is exhibited, in each individual corallum of *Halophragma,* through the loss of the slipper shape, the exact point in time in which the operculum weakened or

19 Lyon, Proc. Nat. Acad. Sci. Phila., **1879**:43 ff.; Roemer, Lethea Geognostica, **2**:385, 3 ed.; Safford, Amer. J. Sci. **29**(2):248, 1860.

20 Richter, R., Die Verhältnisse von Funktionen und Form bei den Deckelkorallen, Senckenbergiana **11**:71-72, 1929.

entirely lost its articulated movement, and with this its formational power. (Writer's translation).

In *Homalophyllum herzeri* the flattening of the corallum is also on the cardinal side, a condition likewise true of *H. ungulum*. The endothecal apparatus of these two species is that normal to the *Zaphrentidae*, and only their flattened coralla make them conspicuous. Both forms possess very deep calices, with a large number of well developed septa, and both have conspicuous cardinal fossulae.

Cyathophyllum exiguum[21] has 35 to 40 septa and a cardinal fossula of moderate size. Its most notable character is the unusual flattening of the cardinal side. In many individuals this feature is so developed as to leave no doubt of its purpose—that of insuring the calyx of an upright orientation. The major septa of *C. exiguum* recurve upwards near the center of the calyx into a columelloid structure very similar to that already described for *Homalophyllum calceolum*.

Zaphrentis compressa Rominger is a species whose morphological characteristics are essentially like those of *Homalophyllum ungulum*.[22]

From the preceding considerations there arises two possible ways of explaining the community of shape possessed by calecoloid corals: (1) It may have been acquired by heritage from a common ancestry, however remote; (2) Environmental adaptations may have impressed upon corals of various lineages a common similarity of external form.

The morphology of the operculated corals has been very carefully studied by Richter,[23] and he has advanced the theory that the flattened side of an operculated coral has arisen as a consequence of the mechanical necessity of a straight hinge line for the articulation of an operculum. Richter opposes the theories of Walther, Yakowlew, and Dacqué, each of whom holds a modification of the idea that the flattened side of the corallum has arisen as a means of giving it definite orientation, i. e., as a "resting surface." As contrary evidence, Richter cites the fact that operculate corals which become colonial, or which develop supporting roots, persist in retaining their calceoloid shape. Among North American corals this phenomenon is especially well manifested by *Calceola attenuata* Lyon.

Richter's theory is plausible in its application to corals which are known to have possessed opercula, but there is also evidence to show that flattened coralla may arise without the functional control of an operculum. Of the forms whose morphology has just been briefly reviewed, *Homalophyllum herzeri, H. ungulum, H. calceolum, Cyathophyllum exiguum* and *Zaphrentis compressa* possess endothecal apparati so well developed as to preclude the idea that they were operculate at any stage in the development of the indi-

21 Lambe, L., Cont. to Can. Pal. 4(2):150, 1901.

22 Hall, J., 12th Rept. Ind. Dept. Geol. Nat. Hist.: 295, pl. 21, figs. 4-5; pl. 22, fig. 5, 1882. Rominger's name is preoccupied by *Zaphrentis compressa* Milne-Edwards and Haime, 1860.

23 Richter, R., op. cit., pp. 56-94.

vidual. That the flattening of *C. exiguum* is essentially related to orientation seems obvious from the direct relationship between the degree of flattening and the position of the calyx. The end point of such a functionally controlled flattening is found in the genus *Palaeocyclus*. Grabau[24] notes that certain modern corals, such as *Manicina*, show a flat base when found upon a hard, sandy sea bottom, while others of apparently the same species develop a pointed corallum when the bottom is of soft materials into which they can sink slightly.

It seems logical to conclude that the calceoloid corals are a polyphyletic group whose convergence is the result of a superficial form impressed by several factors. In the *Calceolidae* and *Halophragma* the shape is a functional accessory of the operculum; in *Cyathophyllum exiguum* the flattening is an adaptation resulting in an upright position of the calyx. In *Homalophyllum calceolum, H. herzeri,* and *H. ungulum* the flattened side appears to be a heritage evidencing true generic relationship, since these corals are not operculated, and the degree of flattening is not sufficient to have an appreciable effect on the position of the calyx.

It is not possible to do more than speculate as to the ancestry of these three latter forms, but *Halophragma* is a logical candidate for this position. *Halophragma* has already been cited as a form evidencing transition from operculated to non-operculated types. Its endothecal structure needs but little modification to give rise to that of *H. herzeri* or *H. ungulum,* and indeed it is almost recapitulated in the early stages of *H. calceolum.* Lastly, it is properly placed in time to have been ancestral to the Devonian forms.

In erecting the genus *Homalophyllum* Simpson perceived the close relationship existing between *Zaphrentis herzeri* and *Z ungula,* but his diagnosis of the genus does nothing more than to define the calceoloid corals as a whole. Even the *Calceolidae* are not excluded, except by implication. . In the preceding discussion it has been shown that the calceoloid corals are not entirely congeneric; Simpson's definition of *Homalophyllum* should therefore be reworded so as to include only those species which are truly related. To that end the foregoing emendation has been proposed.

Genus **Neozaphrentis** gen. nov.

Genotype.—*Zaphrentis tenella* Miller, 17th Ann. Rept. Indiana Dept. Geol. Nat. Res., p. 621, pl. 1, figs. 17-18, 1891.

Description.—Small to large conical to sub-cylindrical solitary corals, curved or nearly straight. Exterior rugose and may be concentrically wrinkled and undulatory; often annulated from rejuvenescence or periodic growth. Calyx shallow to deep. Septa variable in thickness, smooth, non-carinate, straight or distally wavering; in two cycles, but the secondaries may be rudimentary. Not more than 60 major septa, not marginally retracted, extending to the center of the calyx where they may fuse, or disappearing a short distance before reaching the center, which is then occupied by a small open or tabulate area. Cardinal septum recessive in post-neanic stages. Cardinal

24 Grabau, A. W., Pal. Sinica, B, **2**(1): 5-6, 1922.

fossula well developed, variable in position, sub-central or extending to the margin. Tabulae few or numerous, partitioning the whole of the corallum; dissepiments few, and not arranged in definite zones. No columella or central columelloid structure resulting from the fusion of the septa.

Remarks.—O'Connell's revision of the genus *Zaphrentis* seems definitely to establish its type species (*Z. phrygia* Raf. & Clif. = *Caryophyllia cornicula* Leseur) as a form with carinate septa.[25] Accordingly, only by error or oversight could any of the several hundred species assigned to this genus be rigorously considered as belonging therein. The extremely generalized wording of Rafinesque and Clifford's generic description has made *Zaphrentis* easily applicable to a wide variety of tetracorals of primitive type, and in addition the genus has formed a convenient dumping ground for forms apparently lacking in distinctive generic characters.

Milne-Edwards and Haime, Thomson and Nicholson, Carruthers, and numerous other writers have published emendations of the original description of *Zaphrentis*, each endeavoring to include or emphasize those characters which he believed Rafinesque and Clifford meant to pertain to *Zaphrentis*, but failed to note. There have thus grown up definitions of *Zaphrentis sens. lat.*, which, while conforming to a certain general pattern, are readily pliable, and have no precise demarcations except such as may exist in the mind of the individual worker. Evidence of the plasticity of such generic concepts is found in the fact that during the past half century no less than ten genera have been created out of species originally assigned to *Zaphrentis*, and yet but a small fraction of its species has been critically revised.

On the other hand, a tabulation (biometric and morphological) of the characters of 100 species of *Zaphrentis* drawn at random from the works of Milne-Edwards and Haime, Hall, Greene, Worthen, and Miller, leaves no doubt but that a larger number of these forms are congeneric. It appears from this that the popularity of *Zaphrentis sens. lat.*, as evidenced by its widespread usage, arises only slightly from its adaptability to the eccentricities of doubtful species, and essentially because there exist large numbers of tetracorals, truly congeneric, whose generic characters are those of *Zaphrentis* as it is commonly interpreted.

In view of the establishment of *Zaphrentis* in the literature, it may, at first thought, seem advisable to continue the usage of *Zaphrentis sens. lat.* as the generic designation for these species, separating, as the occasion arises, such forms as are found to be generically distinct. Such indeed has been the procedure during the past twenty years. The objections to this method are two: (1) *Zaphrentis sens. lat.* is practically and taxonomically unsound, in that it does not and cannot have a type species. (2) The characters of *Zaphrentis sens lat.* must always be, in final analysis, the result of individual interpretation. Hence it seems better to create new genera, even based on characters of uncertain final value, than to assign species to a genus whose position is doubtful, and whose characters are undetermined.

In the course of the present revision, *Zaphrentis tenella* Miller was found

25 O'Connell, M., op. cit., p. 182.

to be a species whose generic structure coincides with the prevailing generalized interpretation of *Zaphrentis* Raf. & Clif., yet differing from *Z phrygia*, the genotype. The description of *Neozaphrentis*, while drawn from the type species, is therefore essentially that of *Zaphrentis sens. lat.* It is hoped that there may thus be provided a taxonomically sound repository for large numbers of congeneric species now termed *Zaphrentis*.

Neozaphrentis tenella (Miller)

Pl. 9, Figs. 6-8; Pl. 13, Figs. 7-14.

Zaphrentis tenella Miller, Adv. Sheets, 17th Ann. Rept. Indiana Dept. Geol. Nat. Res.: 11, pl. 1, figs. 17-18, 1891.
Zaphrentis tenella Miller, 17th Ann. Rept. Indiana Dept. Geol. Nat. Res.: 621, pl. 1, figs. 17-18, 1892.
Zaphrentis tenella Keyes, Missouri Geol. Surv., 4:111, pl. 13, fig. 10, 1894.

Description.—Corallum simple, turbinate, twisted, moderately curved, regularly enlarging and tapering to an acute point at the base. Surface marked by shallow constrictions of growth and smaller concentric wrinkles. Epitheca not preserved. Calyx deep, very slightly inclined to the long axis of the corallum or nearly transverse, outer wall thin. Septa equal, moderately large, and uniting around a subcentral fossula, that extends to the wall, on the left side of the corallum, and embraces a rudimentary septum. There are twenty-six septa in the specimen illustrated, which is .35 of an inch in diameter.

This species is distinguished by its elongated form, long tapering point and number and position of the septa and fossula

To Millers' above description certain additional diagnostic features may be added. The curvature of the corallum in *Neozaphrentis tenella* is frequently modified by a sharp twist of the tip portion (Pl. 9, Fig. 8) at nearly a right angle. In every individual examined, this twist was toward the right side when the corallum was oriented with the cardinal fossula upward. There seems evidence that the bending of the corallum which produces this twisted tip takes place relatively late in life, as young individuals are quite straight. The apparent uniformity in direction of twisting suggests that it was a means of insuring a definite orientation of the calyx. When the calyx is oriented as above, the cardinal fossula is commonly observed to be displaced toward the left side, although in some specimens it is nearly central in position, and even rarely on the right side.

In mature specimens the primary septa may number as many as 34. Secondary septa are usually absent, even in adults; when visible, they exist as tiny denticulations of the calcinal margin. The cardinal septum is early recessive; the alars are in no way distinguished from the other primaries. The counter septum, in well preserved adults, is the largest and longest septum of the calyx, and stands noticeably higher than the remainder. Hypertrophy of the counter septum is not noticeable in young specimens, and seems associated with the bending over of the corallum, perhaps in the manner suggested by Yakowlew.[26] Dissepiments are exposed where the epitheca has eroded away, but are seldom visible in transverse section. Tabulae occur at

26 Yakowlew, N. N., Geol. Mag., 4(6):108-115, 1917.

rather wide intervals, but partition the corallum completely where they exist.

Internal characters.—(Pl. 13, Figs. 7-14.) In neanic stages the septa display nearly radial symmetry, modified only by a tendency of those of each quadrant to fuse together. They extend well toward the center of the corallum, where their inner edges coalesce, leaving a circular opening bounded by a stereotheca. With expansion of the corallum, this central opening merges with the cardinal fossula, giving this an expanded inner termination. This structure is generally persistent into the adult, except as obscured by tabulae and by the transgression of the counter septum. In youthful stages the cardinal septum extends to the center of the corallum, where it joins the stereotheca; it is somewhat thinner than the other primaries and is rapidly recessive, having nearly disappeared at the close of the neanic stage.

During the ephebic and later periods the radial arrangement of the septa in the cardinal quadrants gives way to a pinnate disposition about the cardinal fossula. The counter septum becomes elongated and thickened, and extends well into the open center of the corallum. Its position is usually excentric,, either to the right or left of a line bisecting the cardinal fossula.

Remarks.—Some stages of *Neozaphrentis tenella* bear a strong resemblance to *Zaphrentis konincki* Edwards and Haime, but the former is much smaller when at the stage of similarity, and possesses a much better developed fossula.

Hypotypes.—31593 Sampson Collection, Walker Museum, University of Chicago.

Horizon and localities.—Chouteau limestone, near Sedalia, Mo., Kinderhook limestone, Louisiana, Mo.

Family *Hapsiphyllidae* Grabau

Simple corals, usually of small size, and of conical or horn-shaped form, straight or curved. Epitheca with growth lines, often with wrinkles and with the septal grooves well marked. In some forms the surface is covered with strong hollow spines. Counter quadrants accelerated, often strongly so, containing in extreme cases four times as many secondaries as the cardinal quadrants. Cardinal septa united by their inner ends to form a secondary wall or phyllotheca, which may also include the alars and secondaries of the cardinal quadrants. The wall may be incomplete, open on the cardinal side with the cardinal septum projecting into the gap or shortened to form a cardinal fossula; or it may be modified by the thickened ends of the septa, or by the development of a median mass of stereoplasm more or less crescentic in transverse section. Tertiary septa indicated or moderately developd. Tabulae when present restricted to the inner area; dissepiments present in most cases, but not abundant.

Genus *Hapsiphyllum* Simpson

Hapsiphyllum Simpson, New York State Mus. Bull. **39**:203, fig. 10, 1900.
Hapsiphyllum Grabau, Pal. Sinica, B, **2**(2):118-120, fig. 21, 1928.

Genotype.—*Zaphrentis calcariformis* Hall, Fossil corals, Niagara and Up. Helderberg groups, p. 33, 1882, and 12th Rept. Indiana Dept. Geol. Nat. Hist., p. 293, pl. 21, figs. 10-11, 1882.

Original description.—Corallum simple, conical or horn-shaped; calyx circular, comparatively deep, with thin margins; biareal. The outer area is bounded by the external epitheca; the inner area by a sub-vertical wall of horseshoe shape, open on the side of the septal fovea. Two larger septa connect with this wall in such a

manner as to apparently be a continuation of it, and form a very distinct pyriform septal fovea; sept alternating in size, the smaller ones continuing for a short distance into the cavity of the corallum, there coalescing with the larger ones, which continue to the inner wall, with which they coalesce, and in which they terminate. Tabulae and dissepiments are present.

The wall of the inner area, connecting with two of the septa and bounding a portion of the septal fovea, is similar to that of *Agonophyllum*, but that genus differs from this in several respects, principally in having carinations on the side of the septa.

Fig. 3. Cross-section of *Hapsiphyllum calcariforme* (Hall) showing the characters of the genus *Hapsiphyllum*. (After Simpson).

The phenomenon of septal acceleration, which in the hands of Grabau and his students has been given widespread application as a means of characterizing coral genera and species, is described by him in the genus *Hapsiphyllum* as follows:

In the genotype, *H. calcariforme* there are 13 septa between the cardinal and counter on each side, making 12 secondaries, but their distribution in the quadrants is not determined. The probabilities however, judging from analogy with other species are that there are four in the cardinal and eight in the counter. The tertiary septa[27] all adhere to the secondaries in the type species, the counter septum having one on each side which is longer than that found in the other septa. In European species however, the tertiary septa are most usually free and often only very slightly developed. The cardinal septum in the type species is very short, but in European and Asiatic species it is often long.

Hapsiphyllum cassedayi (Milne-Edwards)

Pl. 9, Figs. 18, 19, 25; Pl. 13, Figs. 15-20.

Zaphrentis cassedayi Milne-Edwards. Hist. nat. corr., **3**:341. pl. G1, fig. 2, 1860.
Zaphrentis prona Milne-Edwards. Hist. nat. corr., **3**:342, 1860.
Zaphrentis calcariformis Hall, 12th Rept. Indiana Dept. Geol. Nat. Hist.: 293, pl. 21, figs. 10-11, 1882.
Zaphrentis ulrichi Worthen, Geol. Surv. Illinois, **8**:76, pl. 10, figs. 10-10a, 1890.
Zaphrentis cassedayi Greene, Contrib. Indiana Pal., pt 18: 178, pl. 52, figs. 12-18, 1904.
Zaphrentis cassedayi Beede, 30th Rept. Indiana Dept. Geol. Nat. Res.: 1203, pl. 7, figs. 3-3c, 1905.

Description.—Corallum regularly conical, pointed at the base, straight or a little curved. Growth annulations very slightly pronounced. The entire surface is covered with small conical spines, fairly regularly spaced. Calyx circular and deep. Septal fossula large, oblong, very deep, centro-lateral. 24 principal septa, thin, a little unequal, obliquely fusing together by their inner edges, in such manner as to form the wall of the septal fossula. An equal number of septa also well developed, but a little smaller

27 As used by Grabau the term "primary septa" refers only to the four first formed septa of the corallum—the cardinal, counter, and two alar septa. The remaining septa of the first cycle he designates as secondaries, and those of the succeeding (2nd) cycle as tertiaries.

than the preceding ones. When the calyx is placed before the observer in such fashion that the lateral prolongation of the central fossula is downward, one sees that each one of the small septa unites with its large neighbor on the right, in the right-hand portion of the calyx, and with its large neighbor on the left in the left-hand portion. The height of the corallum is about 2 centimeters; the diameter of the calyx 1. (Writer's translation.)

Milne-Edward's preceding description is fairly comprehensive, and a very complete description of the external characters of *H. cassedayi* is given by Beede. (See synonymy above).

Internal characters.—(Pl. 13, Figs. 15-20.) As may be seen in Fig. 20, the internal structure of *H. cassedayi* during the neanic period is entirely different from that characterizing the later stages. In these youthful portions of the corallum the primary septa, of which 13 are visible in the section, extend to the center, where their ends join. The cardinal and counter septa are so nearly continuous as to strongly suggest the original "axial septum" of Carruthers; as though these two, existing first as a single septum stretching across the diameter of the calyx, had not yet broken apart to form the cardinal and counter septa. If this is actually the case the early development of *H. cassedayi* must be much retarded, as the section is from a relatively late neanic stage. The position of the cardinal fossula can be determined only from the location of the cardinal septum. The phyllotheca characterizing the genus *Hapsiphyllum* is not formed until after the neanic period, when it arises through the further insertion of septa, and the bending and fusing of the inner margins of these later-comers. The septal acceleration emphasized by Grabau as a character of the genus is already perceptible in the neanic stage, there being 6 septa in the counter quadrants and only 5 in the cardinal quadrants. Tabulae and dissepiments appear to be absent.

With the continued insertion of septa during the ephebic stage the appearance of the cross-section of the corallum is entirely transformed (Figs. 16-19). The 23 septa of Fig. 19 have produced a phyllotheca which completely walls off an elongated cardinal fossula. The cardinal septum is rapidly receding. In the counter quadrants the development of secondaries is nearly complete, and they are characteristically fused with the adjacent primaries. Secondary septa have not yet developed in the cardinal quadrants, and their formation is considerably retarded, as is evidenced by Fig. 18, in which they may be detected as marginal rudiments. The counter quadrants continue to be accelerated over the cardinal quadrants until the adult number of 24 primary septa is achieved. Fig. 15, a section from a mature stage, exhibits the septal pattern of the calyx, with all secondary septa developed. The characteristic "key-hole" shape of the cardinal fossula, and the full development of its enclosing phyllotheca are here well shown.

Remarks.—The external characters of *H. cassedayi* are distinctive, and have been described frequently and accurately; the extensive synonymy is therefore somewhat surprising. In part this may be traced to the apparent variability shown by this species in the development of a spinose or smooth exterior; in part it is evidently due to lack of familiarity with the literature. It is to be noted that all the species grouped in the synonymy are from the same geologic horizon, and from a relatively restricted area. A seeming ex-

ception is *Zaphrentis calcariformis* Hall, which is assigned by its author to the Corniferous (Onondaga) limestone of the Falls of the Ohio. Worthen, however, states that Hall erred in so assigning it, and that the type is actually from the Warsaw division of the St. Louis limestone. This same formation is also the source of the Milne-Edward's holotype of *Z. cassedayi*, and of the holotypes of the other species here considered identical with *H. cassedayi*.

In keeping with this marked limitation in the horizontal and vertical range of these forms, it may be further observed that *Z. prona* Milne-Edwards, as evidenced by that author's description, differs from *H. cassedayi* only in the absence of epithecal spines. The septal apparatus is stated to be identical in number and disposition in both forms. Aside from the ease with which such delicate and exposed structures as exothecal spines may become obliterated, their presence or absence, unaccompanied by other variation, seems a doubtful basis for specific differentiation. The same considerations are equally applicable to *Z. calcariformis* Hall. The description of this species is in every respect comparable to that of *Z. cassedayi* Milne-Edwards, except for the absence of external spines. Worthen's hypotype for *Z. calcariformis* (Pl. 9, Figs. 18, 25) appears to be a *Hapsiphyllum cassedayi* the exterior of which is smooth, either as a result of erosion or of mutation. *Zaphrentis ulrichi* is stated by Worthen to differ from *Z. calcariformis* Hall only "in its compressed and more rapidly expanding form." These again are characters hardly of specific worth when unsupported by any endothecal differences. Variations in the rate of expansion and the degree of attenuation of the corallum may be observed in profusion among individuals of any species of which a considerable number are compared.

Hypotypes.—26600, Walker Museum, University of Chicago; 2558, Illinois State Museum.

Horizon and localities.—"Corniferous" (?) limestone, Falls of the Ohio; Warsaw division of the St. Louis group, Spergen Hill, Washington County, Georgetown, Floyd County, Lanesville, Harrison County, Paynter's Hill, Bedford, Harrodsburg, Bloomington, Elletsville, Stinesville, and Romona, Indiana; Coalsburg, Kentucky.

Genus **Clinophyllum** gen. nov.

Pl. 9, Figs. 12-14; Pl. 12, Figs. 17-21.

Derivation of name: κλίνω—lean, φύλλον a leaf.

Description.—Corallum medium-sized or small, cornute. Calyx inclined at a high angle to the long axis of the corallum. The floor of the calyx is formed from a smooth, steeply tilted tabula, which may be nearly plane or arched downwards in a broad funnel shape. Septa short, proximally thick, but tapering rapidly to an edge. The counter septum is the largest in the calyx, and its position and prominence is emphasized by a lateral gap between it and each of the adjacent primary septa. In mature individuals these counter gaps are each occupied by a small, pinnately placed secondary septum. In the type species the two secondary septa thus located are the only members of their septal cycle, all the other septa being primaries. The cardinal septum is second only to the counter septum in prominence. It arches above its

neighbors, and extends farther toward the center of the calyx than any other septum of the cardinal quadrants. The alar septa are distinctly smaller than the other primaries, and occupy alar pseudo-fossulae.

Internal characters.—In the early stages the septa are radially symmetrical, and reach to the center. With expansion of the corallum they become marginally retracted, and the central area becomes open. As growth continues the cardinal and counter septa become greatly thickened and strongly differentiated from the remaining primaries. These latter, although very unequal, are of approximately the same order of magnitude. Tabulae are not numerous, but are very complete, and are placed at the same high angle which characterizes the floor of the calyx. All the more mature portions of the corallum are included in the calyx, within which the radial arrangement of the septa is replaced by a radio-pinnate disposition. Dissepiments are absent.

Remarks.— The genus *Clinophyllum* is unusual in the pseudo-pinnate arrangement of the septa of the counter quadrants, which is in a vertical rather than a horizontal plane; in keeping with this inverted character is the strong development of the counter pseudo-fossula. The acceleration of the counter quadrants is evidenced in the type species by the fact that the only secondary septa are inserted adjacent to the counter septum. The high angle of inclination of the tabula forming the floor of the calyx is further diagnostic of the genus.

A calyx steeply inclined to the long axis of the corallum is a not uncommon feature of the mature stages of the many corals. In *Clinophyllum* this trend has become dominant early in the development of the individual, and is apparently responsible for the other peculiarities of the genus. (Compare the theories of Yakowlew and Weissermel).[28]

Clinophyllum chouteaunse (Miller)

Pl. 9, Figs. 12-14; Pl. 12, Figs. 17-21.

Zaphrentis chouteauensis Miller, Adv. Sheets, 17th Ann. Rept. Indiana Dept. Geol. Nat. Res.: 10, pl. 1, figs. 11-12, 1891.

Zaphrentis chouteauensis Miller, 17th Ann. Rept. Indiana Dept. Geol. Nat. Res.: 620, pl. 1, figs. 11-12, 1892.

Zaphrentis chouteauensis Keyes, Missouri Geol. Surv., **4**:112, 1894.

Description.—Miller's original description reads:

Corallum below medium size, slightly curved, rapidly expanding at the sides, and tapering to a point at the base. Usually constricted immediately above the base, and also having shallower constrictions on the convex side, caused by intermittent growth. Epitheca thin. Calyx subovoid, nearly parallel with the long axis of the corallum or standing almost upright; it constitutes nearly the whole of the corallum, for there is only a small point below it. Septa unequal, a few small ones near the margin of the calyx, but they soon fade away; primary septa short and thick in the expanded part of the calyx and coalesce as they approach the base of the cup. There are thirty-two primary septa in the calyx of the specimen illustrated. . . a much smaller specimen has only twenty-four, and larger specimens probably have as many as forty. Septal fossette large, occupying the central part of the calyx and projecting toward the concave side

28 Yakowlew, N. N., op. cit.; Weissermel, W., Zeitschr. Deutsch. Geol. Gesell., **49**:865-888, 1897.

of the corallum. This species is distinguished by its lateral expansion, upright calyx, and short, thick, coalescing septa.

Miller's interpretation of the structure of his species appears to be erroneous in several respects. Since neither the cardinal nor the counter septa are aborted at any stage of development, the formation of a true fossula is impossible. The pseudo-fossula visible in the calyx is occupied by the counter septum, a fact which is verified by an inspection of the rugae. Miller's description of a cardinal fossula rests upon the assumption that the entire calyx is involved in the production of this structure, which would thus be walled by the central tabulate area and projected toward the concave side by the slope of the calicular floor. This interpretation is disproved, however, by the internal structure, which in the mature stages is devoid of any suggestion of a fossula. The survey of a considerable number of individuals reveals specimens in which the floor of the calyx is not infundibulate, but remains nearly plane tabula on to which the primary septa project for a short distance before their termination.

The alar septa are slightly recessive within the calyx, and the development of small gaps between each of them and the adjacent septa produces an impression of alar fossulae. The structures so formed are confined to the wall of the calyx, and disappear at its floor, being in this respect entirely analogous to the counter pseudo-fossula. The counter septum is the largest in the calyx, and in mature individuals there is a secondary septum on either side of it. The cardinal septum is the largest in the cardinal quadrants; its situation is not marked by any depression nor by lateral gaps. The remaining septa of the cardinal quadrants are uniformly spaced, subequal in size, and radially disposed.

Internal characters.—In the earlier ontogeny of *C. chouteauensis* the septa are radially symmetrical and extend to the center of the corallum. In occasional individuals there is a weakly developed cardinal fossula in sections younger than the ephebic stage, beyond which it disappears. As a rule the protosepta are not markedly distinguished from the other primaries during the neanic stages. The youngest section obtained (Fig. 21) exhibits 12 moderately thick septa; dissepiments appear to be absent. During the ephebic period (Figs. 19-21) the elongation of the septa proceeds less rapidly than the expansion of the corallum, so that the septa are pulled toward the margin and a central open space formed. In this stage the sub-equality of the septa is broken by differential thickening of the cardinal and counter septa, which eventually become more than double the width of the next largest septa. The development of broad, highly inclined tabulae first becomes conspicuous in the ephebic period. These completely partition the corallum, and are of considerable thickness, as may be seen from the tabular intercept visible in Fig. 18, Pl. 12. The tabulae dip in the direction of the cardinal quadrants, and the septa of these quadrants fuse onto the tabular surface in a manner similar to that exhibited in the calyx.

Hypotypes.—9679 Walker Museum, Univ. of Chicago.

Horizon and locality.—Chouteau limestone near Sedalia, Mo.

Family *Cyathaxonidae* Milne-Edwards and Haime

Corallum having the septal apparatus well developed; the septa extend without interruption from the base to the summit of the visceral chamber, leaving between themselves cavities which are open throughout their height, presenting neither traverses, nor tabulae, nor synapticulae. The septa of the first order are not notably more developed than the others, and do not form a quadri-branchiate cross as among the majority of the *Stauridae*.

By the great development of the septa and the absence of the endotheca this little group recalls the family of the *Turbinolidae* among the *Madreporaria aporosa*, and it appears to be the representative of these among the *Madreporaria rugosa*. Among the *Stauridae*, the *Cyathophyllidae*, and the *Cystiphyllidae* the endothecal system is always well developed. (Writer's translation).

Genus *Cyathaxonia* Michelin

Michelin, Icon. Zooph.: 258, 1846.

Description.— Corallum simple, free, artfully pedicellated, and having the form of an elongated and curved cone. Epitheca complete. A well developed septal fossula, situated on the side of the greatest curvature of the corallum. Columella styliform and markedly projecting. Septa smooth, numerous, and the majority extending to unite with the columella. (Writer's translation).

Cyathaxonia tantilla (Miller)

Pl. 9; Figs. 15-17.

Zaphrentis tantilla Miller, Adv. Sheets, 17th Rept. Indiana Dept. Geol. Nat. Res.: 11, pl. 1, figs. 23-24, 1891.

Zaphrentis tantilla Miller, 17th Rept. Indiana Dept. Geol. Nat. Nat. Res.: 621, pl. 1, figs. 23-24, 1892.

Zaphrentis tantilla Keyes, Missouri Geol. Surv. **4**:111, 1894.

Cyathaxonia minor Weller, Bull. Geol. Soc. America, **20**:270, pl. 10, figs. 14-17, 1909.

Description.—Miller's original description is:

Corallum very small, moderately curved, elongate, turbinate, regularly enlarging and acutely pointed at the base. Surface bearing a few shallow constrictions of growth. Epitheca thin. Calyx very deep, and mouth transverse, not oblique to the long axis of the corallum. Septa short, equal and uniting in the center of the cavity. The calyx is so deep that I have been unable to see the fossula by looking into it. Where, however, the wall of the calyx is broken away, I have observed a subcentral depression that indicates the position of a small fossula on the convex side of the corallum. There are 24 septa in the specimen illustrated, which is .1 of an inch in diameter; a little larger specimen has thirty septa.

This species is distinguished by its minute size, elongated form, and deep, transverse calyx.

The tiny calyx of *C. tantilla* is almost invariably filled with deposits of sediment, and the details of the septal arrangement within the calyx obliterated. The minuteness of the structures defies cleaning by any of the common methods. In such calices as could be observed there was no evidence of a fossula. The septa are undifferentiated, radially disposed, and exist as low ridges on the inner wall of the calyx. They extend downward nearly vertically until they are obscured by the depth of the calyx. The columella projects at least two-thirds of the height of the calyx, and increases regularly in diameter as it approaches the calicular floor.

Internal characters.—In sections taken near the tip, the columella is revealed as a broad structure occupying the central half of the corallum. The septa are short and thick, and without exception extend to the columella, with which they fuse. They are entirely radial in arrangement, and undifferentiated. There is no suggestion of fossula, tabulae, nor dissepiments. In sections obtained from progressively older portions of the corallum, the columella is observed to decrease steadily in diameter. In the ephebic stages the septa fail to reach the columella, which thus becomes an isolated central structure. The septa of this period have become differentiated into two distinct cycles. Each alternate septum has become about one-third longer than its neighbors, and has increased slightly in thickness. The radial orientation is still perfectly preserved. In sections taken above the base of the calyx the septa are again undifferentiated, and exist as short, sharply edged marginal ridges.

Remarks.—In describing *Cyathaxonia minor* Weller compares his species with *C. tantilla* Miller as follows: "The species is most closely alied to *C. tantilla* (S. A. M.) but is usually more curved and has less strong longitudinal costae." Weller's cotypes are essentially identical with *C. tantilla*, however, except for the "costal" difference he notes, and this latter seems to have resulted solely from the poorer preservation of the exteriors of his specimens, as compared with Miller's.

The absence of a fossula in *C. tantilla* is at variance with the characters designated for the genus *Cyathaxonia*. The strong development of the septal apparatus, the absence of tabulae and dissepiments, and above all the presence of a salient columella, seem to justify its position in this genus.

Hypotypes.—38042, Walker Museum, University of Chicago.

Horizon and locality.—Chouteau limestone near Sedalia, Missouri; Kinderhook (Fern Glen) limestone, Louisiana, Missouri.

Genus **Crassiphyllum** gen. nov.

Pl. 9, Figs. 9-11; Pl. 12, Figs. 12-16.

Derivation of name: crassus—thick; *φύλλον*—a leaf.

Genotype.—*Zaphrentis declinis* Miller, 17th Rept. Indiana Dept. Geol. Nat. Res.: 621, pl. 1, figs. 25-26, 1892. Keokuk group, New Providence, Indiana.

Description.—Corallum small, straight or gently cornute. Calyx small, shallow, often broken by a rudimentary cardinal fossula and always marked by a central circular opening which is smoothly walled by the distal fusion of the septa into a phyllotheca; this latter may be reënforced by deposits of stereoplasm. The tube thus formed is continuous to the tip of the corallum. Septa of a single cycle only, nearly equal in size. Within the calyx the septa are short and proximally thick, but taper abruptly to an edge.

Internal characters.—The structure of the genus *Crassiphyllum* is extremely simple. The corallum is formed from a radial array of short, thick septa, which fuse together about a central opening extending the length of the individual (Fig. 4). Tabulae are entirely lacking, and both the central open-

ing and the interseptal spaces are unbroken throughout their length except for a few marginal dissepiments, which are usually confined to the earlier stages. There is no suggestion of a fossula anywhere in the internal structure, and the septa are consistently sub-equal and radially disposed.

Remarks.—The distinguishing characters of the genus are the absence of well developed fossulae and of tabulae; the thick undifferentiated septa of a single order, and the central opening walled by a phyllotheca. Despite the presence of a few dissepiments, this genus seems to belong naturally in the family *Cyathaxonidae*.

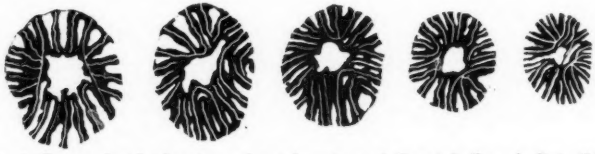

Fig. 4. Camera lucida drawings of serial sections of *Crassiphyllum declinis* (Miller).

Crassiphyllum declinis (Miller)

Pl. 9, Figs. 9-11; Pl. 12, Figs. 12-16.

Zaphrentis declinis Miller, Adv. Sheets, 17th Rept. Indiana Dept. Geol. Nat. Res.: 12, pl. 1, figs. 25-26, 1891.

Zaphrentis declinis Miller, 17th Ann. Rept. Indiana Dept. Geol. Nat. Res.: 622, pl. 1, figs. 25-26, 1892.

Description.—Corallum small, elongate, turbinate, more or less curved, and tapering to a point at the base. Surface with shallow constrictions, caused by intermittent growth, and finer transverse wrinkles or concentric striae. Epitheca thin. Calyx moderately oblique to the long axis of the corallum and rather shallow, margin thick. Septa nearly equal, not alternate, thick within the wall, sharp centrally, not twisted; costae thick, showing externally. Septal fossula not well developed and situated on the convex side of the corallum. There are twenty-four septa in the circumference of a calyx .4 of an inch in diameter.

This species is distinguished by its elongate, turbinate form, coarse sharp septa, and wide costae.

The "costae" mentioned by Miller in his description above are not true costae, which are essentially unknown among tetracorals. In *C. declinis* the epitheca is extremely thin, and sags inward over the interseptal spaces, giving a rib-like prominence to the septa where they are thus reflected upon the exterior of the corallum. The fact that the thin epitheca is commonly removed by erosion and the interseptal spaces incompletely filled by sediments, enhances the resemblance of this feature to costae.

The cardinal septum is located upon the convex side of the corallum. In numerous individuals it may be slightly recessive in the calyx, producing a very small, shallow rudimentary fossula, but individuals are equally numerous in which there is no suggestion of such a structure, and it was probably not functional.

Internal characters.—(Pl. 12, Figs. 12-16). The cross-section of the corallum is oval, often considerably flattened. The septa, from their earliest development are sub-equal and radial, but those parallel to the long axis of the

cross-section are generally of greater length than those paralleling its shorter axis. In Fig. 16, which is from the ephebic stage, there are 17 sub-equal septa, radially arranged. The protosepta cannot be distinguished, either by size or by position. The phyllotheca surrounding the open center of the corallum is completely developed, and there are indications of several rows of dissepiments. Each of the short thick septa shows clearly a light central line marking its center of calcification (Fig. 4). The trace of these lines indicates that the septa tend to fuse into about four groups, such fusion being especially pronounced in the more compressed areas of the corallum. The interior of the corallum exhibits little change from early youth to maturity, (Pl. 12, Figs. 13-16), beyond an increase in the number of dissepiments. In Fig. 12, a section taken acros the base of the calyx, the septa project above the phyllotheca and terminate in a sharp edge. They are markedly thick peripherally, and retain their sub-equality, but conspicuously lack the radiopinnate orientation characteristic of most tetracorals.

Cotypes.—6615 Walker Museum, Univ. of Chicago.

Horizon and locality.—Keokuk Group, New Providence, Ind.

C.—Phylogeny and Distribution

Although an intensive phylogenetic study is beyond the scope of the present paper, a brief general survey of the relationships of the forms studied may be appropriately included.

From both stratigraphic and morphological considerations, it is apparent that in seeking the relatives of the *Zaphrentidae* we need look only laterally and backward. All the members of this family which have been here considered became extinct by the close of the Mississippian, and the family itself is unknown in strata younger than Pennsylvanian. A general phylogeronticism of the corals might be deduced from the remarkable variety of mutations found in the Chouteau (lower Mississippian) formation.

In the morphological development of these forms there is an anticipation of this approaching end. All are marked by a stubborn adherence to ancestral structure—the sole trend discernible among them is conservatism. The distinguishing attribute of the genus *Triplophyllum*, its alar fossulae, is not a structure arising in anticipation of profound modifications, but a primitive characteristic found in the ontogeny of all tetracorals, and here retarded to become a feature of the adult. The genus *Neozaphrentis* even more strictly recapitulates older types. The strong development of the counter septum is again the result of retardation, and the eccentric position of the cardinal fossula has been suggested as an indication of racial senility. The genus *Homalophyllum* likewise owes its characteristically flattened corallum to the inheritance of an ancestral modification, a conclusion borne out by the ancient type of endothecal structure exhibited by its species.

Among the Devonian members of the genus *Triplophyllum* may be mentioned the type species, *T. terebrata* (Hall), and *Zaphrentis edwardsi* Nicholson; the lateral range of the genus is indicated by the probable inclusion here

of *Zaphrentis griffithi* Milne-Edwards and Haime, from the Carboniferous of England, and *Hapsiphyllum altiseptum* Grabau, from the Carboniferous of China, is possibly actually a Triplophyllid.

Homalophyllum ungula (Rominger) and *H. herzeri* (Hall) have already been suggested as ancestral to *H. calceola* (White and Whitfield), and a possible Silurian ancestor of this genus exists in *Halophragma calceoloides* Lds.

That the *Hapsiphyllidae* were widespread during the Carboniferous is demonstrated by the numerous European forms and the many species described from China by Grabau. A close relationship between the *Hapsiphyllidae* and the *Zaphrentidae* seems evinced from the fact that species may be found in either genus which essentially combine the characters of both families, an especially close relationship being discernible between the genera *Triplophyllum* and *Hapsiphyllum*. The *Hapsiphyllidae*, being younger and more progresive in structure, are suggested as an offshoot of the *Zaphrentidae*.

The affinities of *Clinophyllum* are uncertain, and its position in the *Zaphrentidae* is purely tentative. The absence of a true fossula is sufficient to exclude it from this group, yet on the basis of its other morphological characters it seems most closely related to the *Zaphrentidae*.

The numerous Carboniferous representatives of the *Cyathaxonidae* have an unusual member in *Crassiphyllum*. The general morphology of the genus leaves little doubt as to the propriety of its inclusion in the *Cyathaxonidae*. Its structure, however, is peculiar in that the columella usually exhibited by the members of this family has here been replaced by a phyllotheca.

The range during the Mississippian of the species considered in the preceding pages is shown in Fig. 5.

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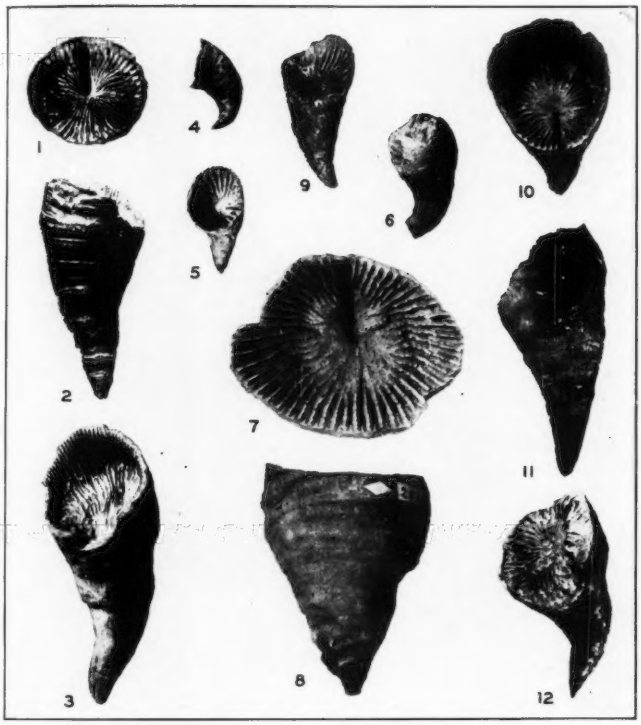
CHICAGO, ILL.

	IOWA SERIES									CHESTER SERIES							
	Kinderhook			Osage		Merimac				Low. Ches.		Mid. Ches.		Upper Chester			
	Louisiana	Hannibal	Chouteau	Burlington	Keokuk	Warsaw	Spergen	St. Louis	Ste. Gen've	Renault	Paint Creek	Golconda	Glenn Dean	Vienna	Menard	Clore	Kincaid
Triplophyllum centralis				*	*												
T. dalii				*	*												
T. cliffordanum			*														
T. welleri			*														
T. spinulosum					*	*		*		*	*	*	*		*		
T. illinoisensis					*												
Homalophyllum calceolum				*	*												
Clinophyllum chout'ensis			*	*													
Neozaphrentis tenella				*													
Hapsiphyllum cassedayi						*	*										
Cyathaxonia tantilla			*		*												
Crassiphyllum declinis					*												

Fig. 5. Stratigraphic distribution of the species considered in the foregoing pages.

PLATE 8



FIGURES

1–3. *Triphlophyllum dalii* (M-E. & H.). Fig. 1 shows the calyx of Worthen's hypotype; Fig. 2 is a lateral view of the same specimen; Fig. 3 is a hypotype showing the curvature of the corallum.

4–5. *Triplophyllum cliffordanum* (M-E. & H.). Calicular and lateral views of Weller's hypotypes.

6. *Triplophyllum cliffordanum hespere* Grove. Cotype showing swollen aspect of upper corallum.

7–8. *Triplophyllum illinoisense* (Worthen). Calyx and convex side of the holotype.

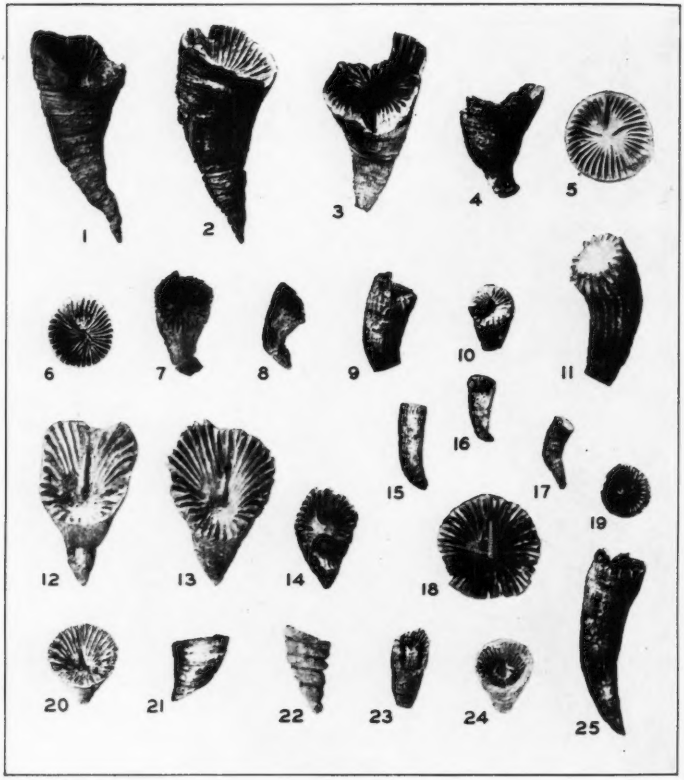
9. *Triplophyllum welleri* Grove. Holotype.

10–11. *Triplophyllum centralis* (M-E. & H.). Fig. 10 is Worthen's hypotype, Fig. 11 another specimen showing convex side of corallum.

12. *Triplophyllum spinulosum* (M-E. & H.). This specimen is Worthen's hypotype of *Zaphrentis spinulifera* Hall.

Fig. 5. Stratigraphic distribution of the species considered in the foregoing pages.

PLATE 9



FIGURES

1–5. *Triplophyllum spinulosum* (M-E. & H.). Fig. 2 is the holotype of *Zaphrentis chesterensis Worthen;* Figs. 3 and 4 are the cotypes of *Z. pellaensis* Worthen. Fig. 5, the calyx of a hypotype, shows the full development of three fossulae.

6–8. *Neozaphrentis tenella* (Miller). Hypotypes.

9–11. *Crassiphyllum declinis* (Miller). Cotypes.

12–14. *Clinophyllum chouteauensis* (Miller). Hypotypes. The eroded epitheca of the specimen shown in Fig. 14 permits a perception of the inclined tabulae.

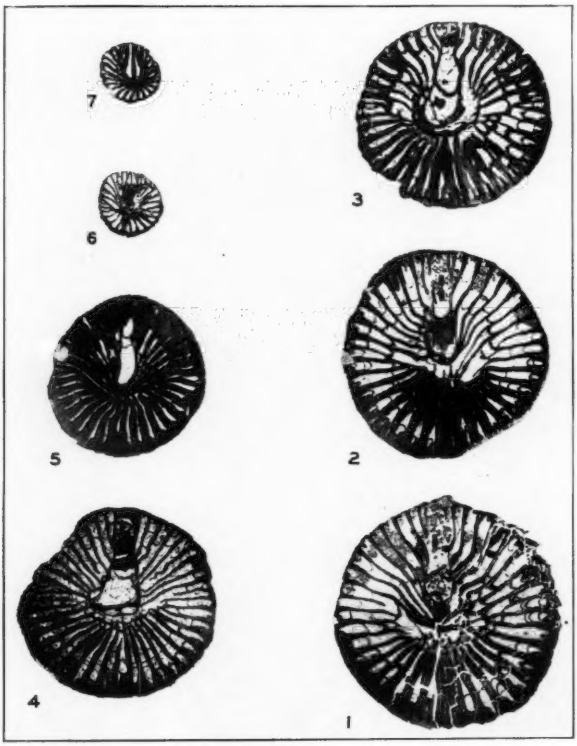
15–17. *Cyathaxonia tantilla* (Miller). Hypotypes.

18–19. *Hapsiphyllum cassedayi* (M-E. & H.). Calicular views of Worthen's hypotypes for *Zaphrentis calcariformis* Hall.

20–24. *Homalophyllum calceolum* (Wh. & Whit.). Hypotypes.

25. *Hapsiphyllum cassedayi* (M-E. & H.). Lateral view of the specimen shown in Fig. 18.

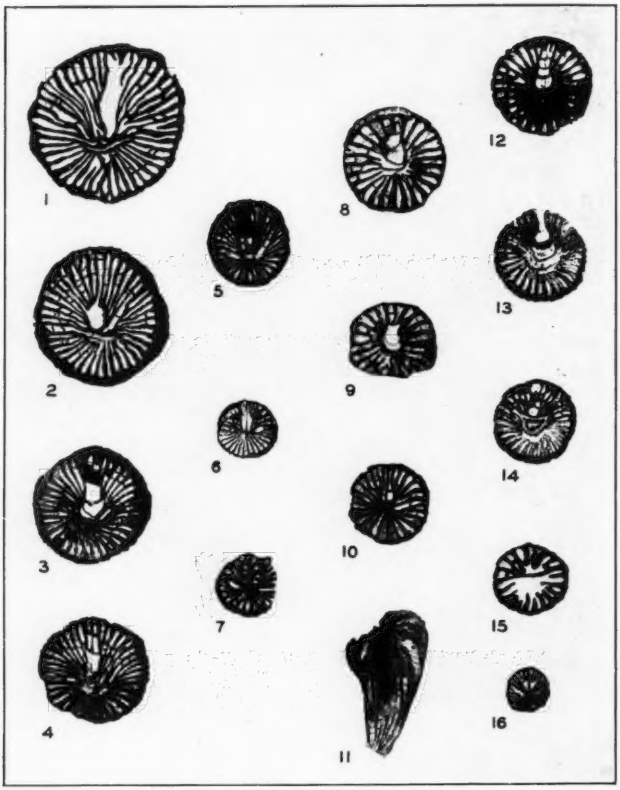
PLATE 10



FIGURES

1–7. *Triphlophyllum centralis* (M-E. & H.). Serial sections illustrating the changes in internal structure from late neanic to adult stages. x2

PLATE 11



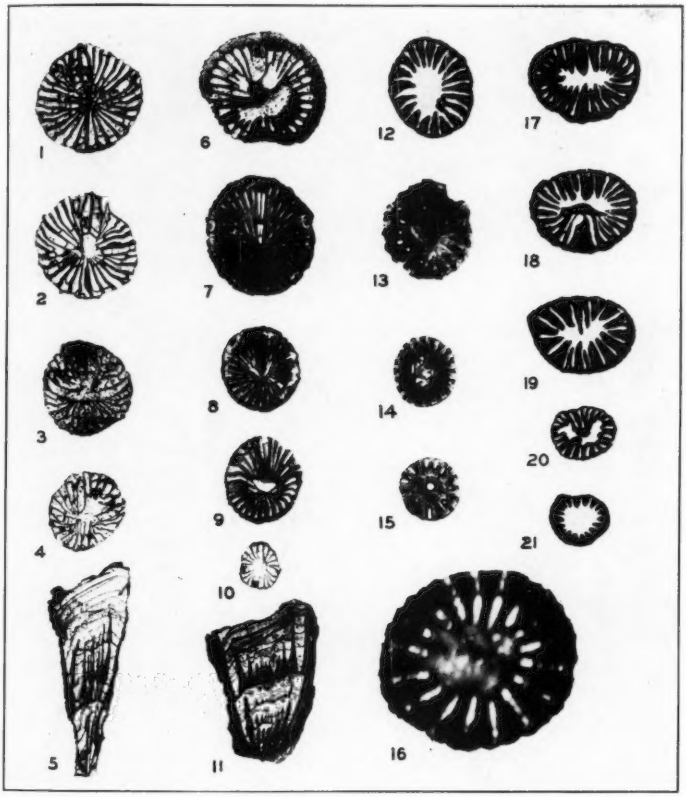
FIGURES

1–7. *Triplophyllum dalii* (M-E. & H.). The serial sections of Figs. 1-6 are magnified 1½ times; Fig. 7 is a tip section enlarged 4 times.

8–11. *Triplophyllum cliffordanum* var. *hespere* Grove. x2.

12–16. *Triplophyllum cliffordanum* (M-E. & H.). Composite serial sections from three individuals. x2.

PLATE 12



FIGURES

1–5. *Triplophyllum spinulosum* (M-E. & H.), var. α. x1½.

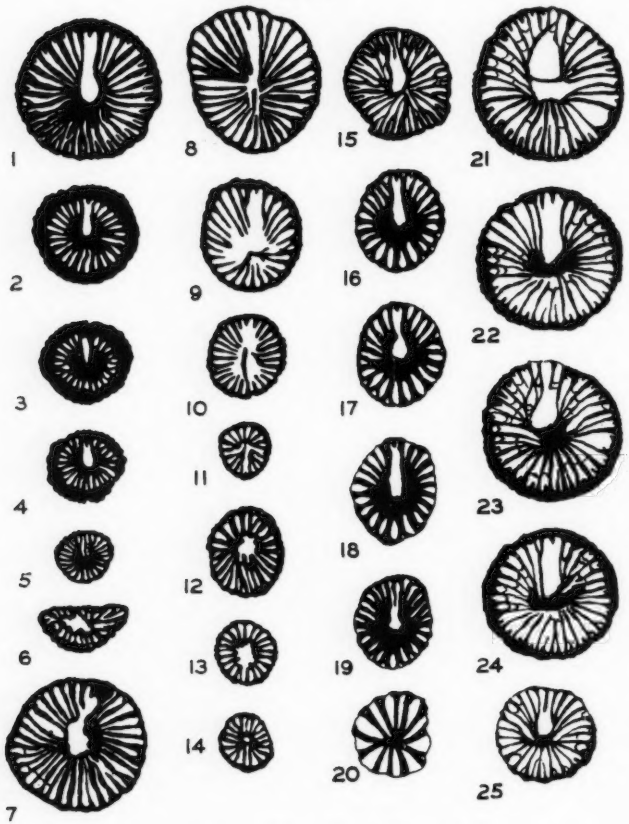
6–10. *Triplophyllum spinulosum* (M-E. & H.). var. β. x1½.

11. *Triplophyllum spinulosum* (M-E. & H.), var. α. x1½. This vertical section is shown for comparison with Fig. 5, and illustrates the uniformity of internal structure which prevails despite dissimilarity in the shapes of the coralla.

12–16. *Crassiphyllum declinis* (Miller). Serial sections, all x2 except Fig. 16, which is a tip section enlarged 12 times.

17-21. *Clinophyllum chouteauense* (Miller). x2.

PLATE 13



1–6. *Homalophyllum calceolum* (Wh. & Whit.). Figs. 1-5 are serial sections of a single individual, and are enlarged 3 times; Fig. 6 is from a neanic stage, and is x4.

7–14. *Neozaphrentis tenella* (Miller). Composite serial sections from a number of individuals, enlarged 3 times.

15–20. *Hapsiphyllum cassedayi* (M-E. & H.). All but Fig. 20 are enlarged 3 times; Fig. 20 is magnified approximately 5 diameters.

21–25. *Triplophyllum welleri* Grove. Serial sections of a cotype. x2.

MIDDLE EOCENE AND OLIGOCENE DECAPOD CRUSTACEANS FROM TEXAS, LOUISIANA, AND MISSISSIPPI*

H. B. STENZEL

I.—Introduction

Decapod crustaceans have in the past been much neglected by workers in the Tertiary of the Gulf Coastal Plain. This is due chiefly to an *embaras de richesse*, because mollusks are so abundant, so diversified, and so well preserved that they have occupied most of the attention of the paleontologists. Crustaceans, on the other hand, are not numerous, but for stratigraphic correlation they seem to be of great importance. With their aid long range correlation is possible.

A good example of the stratigraphic value of the crabs is the range of *Harpactocarcinus americanus* Rathbun. This species was used by the writer[1] in 1931 for zonation in the Crockett formation of the lower Claiborne of Brazos County, Texas, where hundreds of specimens occur. At that time it was believed that this crab zone was merely a local, restricted zone of no value outside of Brazos County. Further search to the eastward, along the outcrop of the Crockett formation, resulted in the finding of this species at many localities in Leon County and at the following three localities east of Leon County:

A. At base of bluff on right bank of Hurricane or Threemile Bayou in the southeast corner of Young-Murchison 553.5-acre tract and H. F. Craddock 277.4-acre tract in southeast corner of Newell C. Hodge survey; 0.3 mile above the bridge over the bayou, which is 3.35 miles north-northeast of the Houston County court house on Crockett-Rusk road (mail route No. 1); Houston County, Texas. (Three specimens)

B. Road cuts on each side of Provencal-Flora-Cypress road, 2.18 miles from Provencal depot or 4.48 miles from Flora railroad crossing; Natchitoches Parish, Louisiana. (Five specimens)

C. Cut of Alabama & Vicksburg Railroad on Indian Mound in pasture of Mr. A. H. Edmonds, ±3 miles east of Newton and south of Highway 80; Newton County, Mississippi. The Edmonds home is located at the entrance to this pasture, on south side of Highway 80, 2.81 miles east of the highway intersection on Newton main street. (One complete specimen and one separate right cheliped)

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* Published by permission of the Director, Bureau of Economic Geology of The University of Texas.

1 Renick, B. C., and Stenzel, H. B., The stratigraphy and paleontology of the lower Claiborne along the Brazos River, Texas. Univ. Texas Bull. **3101**:78, 94-95, 1931.

Stenzel, H. B., Decapod crustaceans from the Middle Eocene of Texas. J. Paleont. **8**:38-56, 1934.

In order to facilitate checking and finding of these fossils by others, detailed sections of the three localtiies are included below:

A. Combined section along Hurricane Bayou above the bridge:

		Feet	Inches
5.	Greenish, conchoidal, unctuous, fairly clean clay	5	
4.	Limonite concretions in gray, glauconitic shale	2	1
3.	Gray, non-glauconitic shale with buff, fine silty layers	8	
2.	Glauconite marl with many *Plicatulae* and *Harpactocarcini*	1	6
1.	Impure, limonitic limestone with *Plicatulae*, fucoids, pipes, and large ripple marks in its lower part. Total thickness not exposed	1	

B. Section in road ditch along Provencal-Flora road:

5.	Deeply weathered clay, reddish-brown on surface, yellowish-buff deeper inside, with many white marl nodules of about a quarter inch diameter: contains also white concretions with many *Harpactocarcini*. Weathers to reddish-brown loamy soil. To top of hill where exposure ends at a curve sign	5	
4.	White to light yellow, marly limestone, weathering into boulders that strew the slopes on both sides of the road	1	6
3.	Light buff clay, deeply weathered, with many white chalky lime nodules of about a quarter inch diameter. *Lobonutus* found here. Weathers to black, waxy soil	6	
2.	Line of hard, white limestone concretions about 8 by 16 inches in size. These concretions are about 6 feet apart horizontally		
1.	Thinly laminated shale with silt partings, dove-gray on weathered surface changing to brownish-gray on fresh surface. Toward the top this shale carries small lime nodules and weathers to black, waxy soil	6	

C. Section in railroad cut on Indian Mound:

6.	Light buff, massive, calcareous, indurated fossiliferous, weathered marl grading upward into brown soil	7	
5.	Light greenish-gray, glauconite-speckled, massive, sandy, fossiliferous marl; forming a vertical wall. A two-inch oyster layer marks the top of this bed	4	
4.	Line of concretions; light greenish gray, finely glauconite-speckled, massive, calcareous concretions. The largest measures 6 by 17 inches		
3.	Poorly bedded, glauconitic, and a little marly sand with scattered fossils, light gray on weathered surface, light greenish-gray when fresh. This bed is darker grayish-green on its surface higher up on the slope	18	
2.	Coarse grained, finely glauconite-speckled, friable sand full of the young of *Ostrea sellaeformis* Conrad. *Harpactocarcinus* found in this bed	1	8
1.	Yellow to gray, massive, clean sand with few irregular limonite streaks and imprints of fossils. Fossil shells largely leached. Total thickness not exposed, to bottom of cut	9	

These localities are situated respectively 80, 200, and 400 miles air line distance east of the type locality of *Harpactocarcinus americanus* in Brazos County. The writer has had no opportunity to search the Crockett outcrops

southwest of the type locality. Therefore, no additional localities are known in Texas to the southwest. But in Mexico, *H. americanus* occurs on "Zardo Creek, about 100 meters downstream from No. 108; Eocene; 1920; Coll. No. M 115 V" according to M. J. Rathbun.[2] This is more than 300 miles air line distance southwest of the type locality in Brazos County. Therefore, the known horizontal range of *Harpactocarcinus americanus* is more than 750 miles measured along the outcrop of the beds. The vertical range of the species in Brazos and Leon Counties, Texas, where the range is known best and also probably greatest, is certainly less than 200 feet.

It is probable that the age of the beds is essentially the same at all localities in which *H. americanus* has been found. Through detailed mapping of the beds Dr. B. C. Renick and H. B. Stenzel proved this to be correct for Brazos and Leon County respectively.[3] For the Hurricane Bayou locality it was proved by reconnaisance work done by the writer in 1932. It was checked for the localities in Louisiana and Mississippi by other paleontological correlations. The most notable of the latter are the correlations of Otto Meyer and T. H. Aldrich,[4] G. D. Harris,[5] A. C. Ellisor,[6] E. A. Wendlandt and G. M. Knebel,[7] H. K. Shearer,[8] C. L. Moody,[9] W. H. Monroe,[10] and F. B. Plummer.[11] According to this correlation the beds near the level of the Little Brazos limestone in the Crockett marl in Brazos and Houston counties, Texas, and the Milams formation of the locality in Natchitoches Parish, Louisiana, and the Wautubbee formation of the locality in Newton County, Mississippi, are at about the same stratigraphic level. All these beds are uppermost lower Claiborne in age.

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2 Rathbun, Mary J., Fossil decapod crustaceans from Mexico. Proc. U. S. Nat. Mus. **78**(8):1, 1930.

3 Renick, B. C., and Stenzel, H. B., op. cit., pp. 73-108. Stenzel, H. B., op. cit.

4 Meyer, Otto, and Aldrich, T. H., The Tertiary fauna of Newton and Wautubbee, Mississippi. J. Cincinnati Soc. Nat. Hist. **9**(2):40-47, pl. 2, 1886.

5 Harris, G. D., Pelecypoda of the St. Maurice and Claiborne Stages. Bull. Amer. Pal. **6**(31) 1919.

6 Ellisor, Alva C., Correlation of the Claiborne of East Texas with the Claiborne of Louisiana. Bull. Amer. Assoc. Petr. Geol. **13**:1339-1341, 1929.

7 Wendlandt, E. A., and Knebel, G. M., Lower Claiborne of East Texas, with special reference to Mount Sylvan dome and salt movements. Bull. Amer. Assoc. Petr. Geol. **13**:1351, 1929.

8 Shearer, H. K., Geology of Catahoula Parish, Louisiana. Bull. Amer. Assoc. Petr. Geol. **14**:440, footnote, 1930.

9 Moody, C. L., Tertiary history of the region of the Sabine uplift, Louisiana. Bull. Amer. Assoc. Petr. Geol. **15**: 535-537, 1931.

10 Monroe, W. H., The Jackson gas field, Hinds and Rankin counties, Mississippi. U. S. Geol. Surv. Bull. **831**:4-5, 1931.

11 Plummer, F. B., Cenozoic systems in Texas, *in* Geology of Texas, Vol I, Stratigraphy. Univ. Texas Bull. **3232**:666, 1932 (1933).

II.—Description of Species

Order DECAPODA

Tribe BRACHYURA

Subtribe BRACHYGNATHA

Superfamily BRACHYRHYNCHA

Family *Xanthidae*

Genus *Lobonotus* A. Milne-Edwards 1863

A. Milne-Edwards, Monog. Crustac. Foss. de la Famille des Cancériens, **1**:279-280, 1861-65.

Genotype.—*Lobonotus sculptus* A. Milne-Edwards from the Middle Tertiary of Santo Domingo; type by monotypy.

Lobonotus natchitochensis[12] sp. nov.

Description of monotype.—The type is an internal mold of the carapace preserved in a white to buff, friable lime nodule. Much of the corresponding external mold of the carapace is also extant.

Carapace broad, wider than long. Antero-lateral margins short, one-half the length of postero-lateral margins. Interorbital width one-third the width of the carapace. No spines on carapace margins.

Carapace divided into well defined areolations by broad, non-tuberculated grooves. The areolations are covered by crowded tubercles. On the internal mold the tubercles are saucer-shaped, with a low center and raised margin; on the external mold the same tubercles are convex with gently arched top and steeper sides.

Epigastric areolations small. A prominent, lone, warty tubercle is located at the inner frontal angle of each epigastric areolation. The median groove that extends to the frontal margin separates these two tubercles from each other and a narrow and deep groove separates each tubercle from the adjoining epigastric areolation. Protogastric areolation large and subtriangular. Mesogastric and metagastric region covered by an areolation that is pentagonal in outline and extends in front into a long narrow constriction, which ends 3 mm. behind the frontal margin. A shallow and inconspicuous groove separates the metagastric region from the urogastric areolation. Urogastric areolation small, transversely elongate, covered by few tubercles, and much lower than the surrounding areolations. Cardiac areolation large and broad, ending backward into three short extensions. The median extension is straight; the lateral ones curve toward the median. The elevation occupying the intestinal region is continued laterally over the branchial region and is narrow and transverse, widest at the outer ends. Metabranchial areolations transversely elongate. Mesobranchial areolations very small and triangular. Epibranchial areolations obliquely elongate and with a short groove near the outer end. Hepatic areolations small and nearly circular. There is a very small areolation outside of the epibranchial areolation and wedged in between the hepatic and epibranchial areolations. This areolation is bluntly pointed forward and out-

[12] Specific name taken from the type locality in Natchitoches Parish, Louisiana.

ward at the margin of the carapace and occupies the lateral extremity of the carapace. The point projects barely beyond the carapace margin.

Interorbital front advanced, truncate, and roughly granulate at the frontal margin. The lower margins of the orbits project beyond the upper margins so that the orbits point obliquely forward, outward, and upward. Orbits only medium-sized and less than twice as long as broad. Orbital margins roughly granulate, similar to the interorbital margin. The granules are arranged in groups that are separated by smooth grooves. The upper orbital margins have the following granule groups and grooves listed in outward progressing order: small group of granules, shallow groove, small group, shallow groove, small group, deep groove, larger group, deep groove, larger group. The first larger group lies in front of the carapace groove that separates the protogastric from the hepatic region. The granules of the frontal and orbital margins are separated from the adjoining areolations of the carapace by a broad, non-tuberculate groove. Above the posterior margin of the carapace there is a row of fine bead granules.

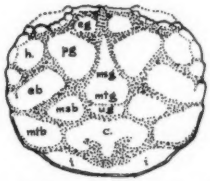

Fig. 1. Diagram of the carapace areolations of *Lobonotus natchitochensis;* eg = epigastric, pg = protogastric, msg = mesogastric, mtg = metagastric, ug = urogastric, c = cardiac, i = intestinal, h = hepatic, eb = epibranchial, msb = mesobranchial, mtb = metabranchial.

Dimensions.—Length of carapace in median line, 17 mm.; greatest width of carapace, 19.5 mm.

Type locality.—Near Provencal, Natchitoches Parish, Louisiana. (See above for more detailed description of the locality.)

Horizon.—Middle Eocene, lower Claiborne group, Cook Mountain division, Milams formation.

Types.—The two parts of the monotype are in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

Diagnosis.—Readily noticeable differences in the ornamentation of *Lobonotus sculptus* A. Milne-Edwards, [13] *L. mexicanus* Rathbun, [14] and *L. natchito-*

---

13 Milne-Edwards, A., Histoire des Crustacés Podophthalmaires Fossiles, tome 1, Monog. d. crust. Foss. d. l. Famille des Cancériens, première partie, 1861-1865: 279-282, pl. 18, figs. 1, 1a, 1b.

Rathbun, Mary J., West Indian Tertiary decapod Crustaceans. Publ. Carneg. Inst. **291**(5):177-179, pl. 6, figs. 6, 7; pl. 7, figs. 10-13; pl. 8, figs. 4-7, 1919; as *Archaeopilumnus caelatus* spec. nov.

———, ———, Additions to West Indian decapod Crustaceans. Proc. U. S. Nat. Mus. **58**: 384, 1920.

14 ———, ———, Fossil decapod Crustaceans from Mexico. Proc. U. S. Nat. Mus., **78**(8): 2-3, pl. 1, figs. 1-3, 1930.

chensis are found along the antero-lateral margins, on the superior orbital margins, and in the epibranchial and intestinal areolations. Along the antero-lateral margin, *Lobonotus sculptus* has 5 sharp spines, *Lob. mexicanus* has 5 blunt and projecting teeth, *Lob. natchitochensis* has but 1 nonprojecting tooth at the lateral extremity of the carapace. The superior orbital margin in *L. sculptus* has 2 fissures, in *L. mexicanus* 2 furrows, in *L. natchitochensis* there are 2 shallow, smooth grooves separating tubercle groups. The epibranchial areole in *L. sculptus* is large, rounded, and well defined toward the carapace margin; in *L. mexicanus* it is large, oblique, and separated by a groove from the fifth tooth; in *L. natchitochensis* it is narrow, oblique, and separated only partially from the fifth "tooth," which in this species does not project. The intestinal areolation of *L. sculptus* is very long and of uniform width, in *L. mexicanus* and *L. natchitochensis* it is much shorter and at the ends wider than in the middle.

Lobonotus brazosensis[15] sp. nov.

Description of monotype.—The type is a right manus and carpus. The carpus is short, stout, and densely covered with tubercles. Its proximal angle is rounded and rectangular. The inner angle is extended into a spine that carries some small tubercles and at its end a spinule. There are two shallow grooves on the carpus. One groove is largely free of tubercles and parallels the tuberculate distal edge of the carapace. It separates the outer surface of the carpus from the manus-carpus joint. The other groove is inconspicuous, shallow, and only partly free from tubercles. It extends longitudinally nearly through the middle of the outer or upper surface of the carpus and disappears proximally. The manus is inflated and increases in height distally. The surface of the manus is largely smooth. Tubercles are restricted to the upper margin and proximal end of the outer surface. The belt of tubercles along the upper margin stops abruptly toward the inner surface but grades off toward the outer surface. A raised and finely tuberculate lobe overlaps the manus-carpus joint at the proximal end of the upper margin. A finely tuberculate lobe overlaps the manus-carpus joint at the proximal end of the lower margin of the manus. Between these two lobes the outer surface of the manus forms a blunt, proximal angle that is emphasized by a group of 4 high tubercles. There is also a group of low, small tubercles at the extreme proximal edge of the manus near its articulation. This edge is separated by a broad smooth groove from the two lobes and the outer surface of the manus. The lower margin of the manus is smooth, polished, thick, and sinuous. The margin narrows very much as it goes over into the sinuous lower margin of the fixed finger which is deflexed by 16 degrees. This finger is slightly hooked at the end and carries a row of twelve closely-set small teeth on the occludent margin. The second, fifth, and ninth teeth are larger than the others. The eighth and tenth are very small: mere tubercles. From the tip of the fixed finger there runs a pitted groove on the outer and inner surface of the finger

15 Specific name taken from the type locality on Brazos River.

parallel with the lower margin. The grooves disappear proximally, on the finger. The groove on the inner surface is more marked than the other. The inner surface of the fixed finger carries a row of 6 pits near to and parallel with the occludent margin and between this margin and the pitted groove. Correspondingly, the outer surface of the fixed finger carries a row of 9 pits adjoining to and parallel with the occludent teeth. There are also some rows of widely scattered and shallow pits along and above the lower margin of the manus on inner and outer surface. These pits are so widely scattered that their arrangement in rows becomes obscure. The rows extend from the fixed finged out on the manus in longitudinal direction.

The dactylus is smooth except for a group of about 16 small tubercles and granules at the proximal end of its upper margin. Occludent teeth similar to those in the fixed finger. The inner surface of the dactylus carries a longitudinal pitted groove through its middle. The outer surface is smooth but for rows of widely separated and shallow pits. Tip is missing.

Dimensions.—Height of manus at distal end, 6.7 mm.; length of manus from interdigital sinus to proximal outer angle, 9.6 mm.; thickness in middle of manus, 4.2 mm.; length of fixed finger, 6.0 mm.; length of carpus, 5.5 mm.

Type locality.—Stone City, on right bank of Brazos River and below the bridges, Burleson County, Texas.

Horizon.—Middle Eocene, lower Claiborne group, Crockett formation, bed (ad) of Stone City section.

Type.—Holotype in writer's collection at the Bureau of Economic Geology, Austin, Texas.

Diagnosis.—A comparison with *Lobonotus natchitochensis* is not possible because the manus of the latter is unknown. It is possible that both belong to the same species. To assume this would be unsafe on account of the large distance between the two type localities. The manus of *L. sculptus* A. Milne-Edwards has 6 to 7 irregular rows of spines on the outer surface of the manus. *Lobonotus mexicanus* Rathbun has longitudinal rows of spines or tubercles on the outer surface of the manus, although it may be less rough than in *L. sculptus*. *Lobonotus brazosensis* has the outer surface of the manus smooth with the exception of the tubercles along the upper margin and the proximal end.

Genus *Harpactocarcinus* A. Milne-Edwards 1862

A. Milne-Edwards, Histoire des Crustacés Podophthalmaires Fossiles, 1862, tome 1, Ann. Sci. Nat., ser. 4, Zool. **18**:46 and 64.

Genotype.—*H. punctulatus* (Desmarest).

Harpactocarcinus americanus Rathbun emend. Stenzel

Harpactocarcinus americanus Mary J. Rathbun (partim), Two new crabs from the Eocene of Texas, Proc. U. S. Nat. Mus. **73**(6), 1928. Females, holotype and paratypes a and b; not paratypes c, d, and f.

Xanthopsis americana (Rathbun), in M. F. Glaessner, Crustacea decapoda, Fossilium Catalogus, I, Animalia, **41**:395, 1929.

?*H. americanus* M. J. Rathbun, Fossil decapod crustaceans from Mexico, Proc. U. S. Nat. Mus. **78**(8):1, 1930.

H. americanus Rathbun emend. Stenzel, in B. C. Renick and H. B. Stenzel, The lower Claiborne on the Brazos River, Texas, Univ. Texas Bull. **3101**:94, 99, pl. 7, fig. 18, 1931.

H. americanus V. van Straelen, Sur des Crustacés décapodes cénozoiques du Venezuela, Mus. roy. Hist. nat. de Belgique Bull., **9**(10):10-11, footnote 5, 1933.

H. americanus Rathbun emend. Stenzel, in H. B. Stenzel, Decapod crustaceans from the Middle Eocene of Texas, J. Paleont. **8**(1):42-45, pl. 6, figs. 1a-e, 1934.

Description.—For detailed description see M. J. Rathbun, 1928, and H. B. Stenzel, 1934. Van Straelen, 1933, gives a critical discussion of the generic position of this species. The Mississippi specimen has more pronounced swellings on the carapace than the types.

Localities.—The type locality is along the banks of Little Brazos River, 0.1 to 0.3 mile above the new concrete bridge of State Highway No. 21 (Bryan-Caldwell road) and about 9.6 miles west of Bryan, Brazos County, Texas (about 100 specimens).

In bed of a branch of Campbell's Creek, directly adjoining the old San Antonio-Nacogdoches trail, 2.85 miles northeast of its junction with State Highway No. 6 (Bryan-Hearne road), at the northwest boundary of Brazos County, Texas (2 specimens).

In the north ditch of the old San Antonio-Nacogdoches trail, 2.7 miles northeast of its junction with State Highway No. 6 (Bryan-Hearne road), and in the Byer 65-acre tract, near the southeast corner of Skeagh Walker survey, on the southeast boundary of Robertson County, Texas (2 specimens).

Many localities in southern Leon County, Texas.

Hurricane Bayou, 3.35 miles north-northeast of Crockett, Houston County, Texas (3 specimens).

Near Flora, Natchitoches Parish, Louisiana (5 specimens).

Indian Mound, 3 miles east of Newton, Newton County, Mississippi (1 complete specimen and one right cheliped).

Horizon.—Middle Eocene, Claiborne group, uppermost part of the lower Claiborne; in Texas in the Crockett formation, near the level of the Little Brazos limestone; in Louisiana in the Milams formation; in Mississippi in the Wautubbee marls.

Types.—Holotype (No. 369607) and paratypes a and b of Rathbun in U. S. National Museum. Figured specimens of Stenzel and many additional topotypes in the writer's collection at the Bureau of Economic Geology, Austin, Texas. Topotypes in the Musée royal d'Histoire naturelle de Belgique, Brussels, Belgium, and in the Geology Departments of Cornell University, Ithaca, New York, University of Texas, Austin, and Agricultural and Mechanical College of Texas, College Station, Texas.

Family *Portunidae*

Genus *Portunus* Weber 1795

Weber, Nomenclator entomologicus, p. 93.
Genotype.—*P. pelagicus* (Linnaeus).

Portunus (?) vicksburgensis sp. nov.

Description of holotype.—The specimen is a black carapace whose sides and rear are missing. The chelae are incomplete at proximal ends.

Frontal margin bears four teeth exclusive of the inner supraorbital teeth and is much advanced beyond the orbits. The frontal teeth are slender but end bluntly. The inner teeth point forward and slightly outward; the outer two teeth point forward and are less advanced. The interspaces between the teeth are broad and U-shaped. The orbits are small, only about one-third of the interorbital width. At the inner angle of the orbit there is a short, blunt tooth. The tooth at the outer angle of the orbit is missing in the specimen. The upper orbital margin recedes in semicircular outline between the inner orbital and a short, blunt supraorbital tooth and is interrupted by a fissure, which is near the supraorbital tooth. Fronto-lateral margins are incomplete in this specimen. At the left side there are four slender pointed teeth of equal size; a fifth tooth is indicated but largely broken off. Apparently there were more than five, possibly as many as eight, teeth on the fronto-lateral margins. The interspaces between the teeth are wide and U-shaped.

Carapace gently arched. The different regions are shown as low swellings. Protogastric regions are low, broad swellings separated from each other by a shallow groove that runs to the frontal margin. A transverse gastric ridge is barely indicated. Mesogastric and metagastric regions are covered by a more pronounced, well defined, and continuous swelling which is higher near the front. This swelling carries on the rear slope two small pits situated near the mid-line and only 2 mm. apart from each other. There is a low, ill-defined ridge that probably starts at the missing lateral tooth of the carapace, runs inward and forward, and becoming more pronounced, bends gradually backward to a point just behind the broadest part of the mesogastric region where it forms a large, broad tubercle. This tubercle is one of three blunt, conical tubercles which make an almost equilateral triangle. The second tubercle, the best defined of the three, is situated at the inner mesobranchial angle, and the third, the lowest, lies outward and forward of the second one in the mesobranchial region. Hepatic region occupied by a slight swelling. Epibranchial region is low and depressed. Branchio-cardiac grooves are deep near the mesogastric region, shallow and broad to the anterior.

Chelae unequal, stout, and finely granulate to smooth. Manus cylindrical to prismatic and swollen. There is a very low, medial, longitudinal ridge on the outer surface of the manus. This ridge disappears distally. Upper surface of manus flat and bounded by a low, longitudinal ridge on each side. These two ridges rise distally into elongate, low tubercles, of which the inner one is the higher. Lower margin of manus thick and rounded. Inner surface swollen and carrying a very low, medial, longitudinal ridge that flattens out distally. Fingers long and narrow.

Dactylus of left manus carries on its upper surface two rounded ridges that are separated by a rounded groove. A third rounded ridge is located on the outer surface. All these grooves and ridges extend only one-third of the length of the dactylus and disappear distally. Dactylus of right manus has the same ridges and grooves, but they are very broad and indistinct due to the larger size of the right dactylus. Prehensile edges of fingers armed with many small, unequal teeth. There is a large conical tooth near the base of the right dactylus. Imprint of part of the left carapace present in the rock matrix. It has a spine at the inner angle.

Description of paratype.—The specimen is a nearly complete interior mold of the carapace in limestone. Only the front of the original carapace is preserved.

Size smaller than the holotype. Lateral tooth of carapace extends outward and is much larger than the other marginal teeth. There are eight antero-lateral teeth including the postorbital and lateral teeth. Postorbital tooth very similar to the other antero-lateral teeth and separated from the adjoining supraorbital tooth by a fissure. Supraorbital tooth about one-half as long as the postorbital tooth.

Areolations of the carapace more pronounced than in the holotype. Protogastric regions carry a narrow and blunt transverse ridge. Cardiac region high, with two transverse tubercles lying near the frontal part of the cardiac region.

Dimensions.—Holotype: interorbital width, 15.5 mm.; width of orbits, 5 mm.?; length from base of frontal teeth to urogastric region, 29 mm.; height of right manus at distal end, 17.6 mm.; height of left manus at distal end, 14 mm.; greatest known thickness of right manus, 12.7 mm.; length of left fixed finger, 18 mm. to broken tip, probably 19 mm. in complete state. Paratype: interorbital width, 10.4 mm.; width of orbits, $\pm$ 3 mm.; length from base of frontal teeth to urogastric region, 20.4 mm.; width of carapace to base of lateral spines, 48 mm.

Localities.—Banks of Mint Spring Bayou, just south of the wall of the National Military Cemetery, in Vicksburg, Warren, Mississippi, above the waterfall and about 100 feet below the lower street bridge over this creek (holotype). In cut of Illinois Central Railroad, 2 miles southeast of depot at Plain, Rankin County, Mississippi (paratype).

Horizon.—Lower Oligocene, Vicksburg group.

Types.—Holotype and paratype are in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

Diagnosis.—In some features of carapace ornamentation *Portunites triangulum* Rathbun[17] is very similar to this species. These similarities are the low, ill-defined ridge that runs from the lateral tooth to near the mesogastric region, the three tubercles that form an almost equilateral triangle near the branchial angle, and the two pits on the meagastric swelling. However, *Portunus vicksburgensis* lacks other, small tubercles that are on the carapace of *P. triangulum*.

17 Rathbun, Mary J., The fossil stalk-eyed Crustacea of the Pacific slope of North America: U. S. Nat. Mus., Bull. **138**:68-71, pl. 17, figs. 3-6, 1926.

These similarities to *Portunites triangulum* set the new species apart from all other American fossil *Portunus* species. The presence of only 8 anterolateral teeth is unusual for the genus. It is not certain whether this feature is constant in the species and it is best to await the finding of better preserved specimens before one may rely on this feature.

Tribe ANOMURA
Superfamily THALASSINIDEA
Family *Callianassidae*
Genus *Callianassa* Leach 1814

Leach, Edin. Encyc., 7:400, 1814.
Genotype.—*Callianassa subterranea* (Montagu).

Key to the species of Callianassa from the Middle Eocene of Texas and Mississippi based on the left manus

A1. Lower margin of manus thick and rounded, no ridge or raised line; inner and outer surface of manus of equal convexity_____C. *burlesonensis* sp. nov.
Basal Crockett formation, Texas

A2. Lower margin of manus sharp, with raised line or ridge; inner and outer surfaces of unequal convexities
B1. Manus much longer than high
C1. Sharp raised ridge extending from outer and upper edge of fixed finger onto outer surface of manus; proximal end slants obliquely upward and proximally; pits of row on inner surface below upper margin slit-like and ventical _____C. *brazosensis* Stenzel
Lower Crockett formation, Texas

C2. No sharp raised ridge on fixed finger or outer surface of manus; proximal end vertical; pits of row on inner surface below upper margin round
D1. Upper and lower margins converging distally; interdigital sinus narrow _____C. *wechesensis* Stenzel
Weches glauconite of Texas and Enterprise glauconite of Miss.
D2. Upper and lower margins very nearly parallel; interdigital sinus wide _____C. *gamma* sp. nov.
Enterprise glauconite of Mississippi

B2. Manus very nearly as high as it is long
C1. Proximal end vertical; hair pits on inner surface along lower margin slit-like; granules between these pits obsolete; inter-digital sinus without tubercles _____C. *beta* sp. nov.
Enterprise glauconite of Mississippi

C2. Proximal end oblique upward and distally; hair pits on inner surface along lower margin round; granules between these pits prominent; interdigital sinus with tubercles on both sides_____C. *alpha* sp. nov.
Enterprise glauconite of Mississippi

Callianassa burlesonensis[18] sp. nov.

Description of holotype.—The holotype is a large (male?) left manus whose proximal end is somewhat weathered. The manus is nearly twice as long as it is high. The proximal end seems to have an acute angle with the upper margin and an obtuse one with the lower margin. Except for the ends which are bent down, the upper margin is nearly straight in outline but with a slight concavity near the distal end. Lower margin conspicuously convex in longitudinal outline. Inner and outer surface equally inflated so that it is impossible to distinguish one from the other by their convexities. Cross section through the middle of manus evenly oval, because the upper and lower margins are both blunt to evenly rounded. Both surfaces are free of tubercles. But both surfaces have a zone of very subdued granulation parallel to the lower margin and about one-third of the height of the manus removed from the lower margin. Along the upper margin are two longitudinal rows of large pits; one containing 9 pits is located at the crest of the margin; another containing 11 pits is located one-half millimeter below the crest on the inner surface. This row bends down a little distally and becomes slightly irregular at the distal end. The inner surface has a solitary slit-like pit at the edge of the dactylus articulation one-third of the height removed from the upper distal point, and two pits in a short horizontal row in the middle of the distal third of the manus. There are four pits in a row through the middle of the inner surface of the fixed finger and the adjoining palm surface. The crest of the lower margin carries 21 tubercles, 16 on the palm and 5 on the fixed finger. The outer surface carries 12 pits in a longitudinal row about one millimeter above the lower margin, 10 on the palm and 2 on the fixed finger. A row of 8 pits extends through the entire length of the palm on the outer surface at about two-fifths of its height. There are two pits at the edge of the dactylus articulation. The occludent margin of the fixed finger has a ridge studded with crowded granules that is accompanied by a row of pits at each side. Each row has three pits on the preserved part of the finger. There is one more solitary pit on the outer surface of the fixed finger.

Description of paratype.—This is a small (female?) right manus, five-sevenths of the size of the holotype. The paratype is closely similar to the holotype even in the number of pits in each row as far as this is ascertainable. The well preserved proximal end of the manus slants as indicated for the holotype.

Dimensions.—Holotype: length of manus to interdigital sinus, 13 mm.; greatest height, 8.2 mm.; height at distal end, 6.8 mm.; greatest thickness, 4.6 mm. Paratype: length of manus to interdigital sinus, 11.1 mm.; height at distal end, 5.1 mm.; greatest thickness, 3.2 mm.

Type locality.—Stone City, on right bank of Brazos River and below the bridges, Burleson County, Texas.

Horizon.—Middle Eocene, lower Claiborne group, Crockett formation, bed (ad) of Stone City section.

Types.—Holotype and paratype in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

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18 Specific name taken from the type locality in Burleson County.

Callianassa alpha sp. nov.

Callianassa wechesensis Stenzel, Decapod crustaceans from the Middle Eocene of Texas, J. Paleont. 8(1):55, pl. 7, fig. 4b, 1934. Paratype 3 only.

Description of holotype, left manus.—The manus is approximately as long as it is high. Proximal end makes an obtuse angle with the upper margin and an acute angle with the lower margin. Upper margin nearly straight, descending very slightly at the distal end, and making a simple, inconspicuous, rounded lobe at the proximal end. This lobe is broken in the holotype. Lower margin is obliquely turned inward and sigmoidal in outline, in general ascending distally and making proximally a conspicuous, rounded lobe, which is produced backward beyond the line of the manus-carpus articulation. Outer surface evenly convex from top to bottom. Inner surface gently convex in the middle of the manus, concave below at a line about three-tenths of the total height removed from the lower margin, and very gently convex again within the lower three-tenths of the height of the manus. Both outer and inner surfaces equally little convex from end to end. Outer surface weathered in the middle. Therefore, no ornamentation is noted there. Outside of the weathered area there are no tubercles except near the interdigital sinus. Near the interdigital sinus there is a group of about 23 low rounded tubercles on the outside surface. Inner surface very well preserved and free of tubercles except at the interdigital sinus. This place is occupied by a crescentic group of about 36 elliptical to rounded tubercles. The prongs of the crescentic group ascend toward the fingers, the one prong merges with the granules at the edge of the aperture for articulation of the dactylus, the other prong ascends the fixed finger, which is broken off near its base. Lower margin of manus densely beaded to serrate. Between the beads are small, distally pointing hair pits. The average distance from bead to bead is 0.42 mm. One-half mm. above the lower margin and parallel to it on the outside surface there are 5 small hair pits. The average distance from pit to pit is 1.4 mm. Upper margin bears a fine, longitudinal ridge over its entire length. Immediately adjoining the ridge on the inner surface there are several, probably 9, fine, distally pointing hair pits. These pits are widely spaced, their average distance being 1.08 mm. Immediately adjoining the upper ridge on the outside surface there are several, probably 7, small pits or hair sockets. They are 1.3 mm. apart as an average. Fixed finged rather slender as far as it is preserved. Dactylus apparently rather bulky at its base to judge from the orifice of its joint. Interdigital sinus rounded and wide.

Description of paratype, left manus.—This rather weathered specimen is much larger than the holotype. It is very similar, differing only in the more pronounced inward flare of the lower margin especially at its proximal end. Therefore, the inner surface of the manus is strongly concave just above the lower margin.

Dimensions.—Holotype, left manus: length to the interdigital sinus, 10.7 mm.; height at proximal end, 10.5 mm.; height at distal end, 9.4 mm.; greatest thickness of manus, 4.2 mm. Paratype, left manus: length to interdigital sinus, 14.4 mm.; height at proximal end, 13.3 mm.; height at distal end, 12.8 mm.; greatest thickness, 5.3 mm.

Localities.—On right bank of Chickasawhay River, 0.2 mile below the steel bridge at Enterprise, Clarke County, Mississippi (type locality, holotype and paratype). On outlier of Weches formation in Mrs. Louisa Gamble 176-acre tract, Joshua Townsend Survey, on Marquez-Flynn mail route, 5.75 miles east of Marquez, Leon County, Texas.

Horizon.—Middle Eocene, lower Claiborne group; in Mississippi in the Enterprise glauconite marl of E. N. Lowe[19] at the base of the Winona formation of C. W. Cooke;[20] in Texas in the Weches formation.

Types.—Holotypes and one paratype from the type locality in Mississippi and one paratype from the Texas locality in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

Callianassa beta sp. nov.

Description of monotype, left manus.—The manus is approximately as long as it is high. Proximal end makes a right angle with both, upper and lower, margins. Upper margin gently convex, descending toward the distal end and making a simple, inconspicuous, rounded lobe at the proximal upper corner. Lower margin very slightly sigmoidal in outline, ascending toward the distal end and making proximally a simple, fair-sized, rounded lobe which is produced backward but a little beyond the line of the manus-carpus articulation. This lower lobe is produced backward not more than the upper lobe. Outer surface evenly convex from top to bottom. Inner surface gently convex in the upper two-thirds of the height of the manus and gently concave in the lower one-third of the manus. Both surfaces equally little convex from end to end. Outer and inner surfaces smooth and free of tubercles even at the interdigital sinus. Lower margin of manus sharp and broken by widely-spaced, much elongate to slit-like, hair pits. These pits are 1.02 mm. apart as an average and there are 13 pits on the preserved part of the margin. Between the pits the margin is only very slightly raised, not producing any serration or beading of note. One half mm. above the lower margin and parallel to it on the outer surface there are 7 small, irregularly spaced hair pits, average distance from pit to pit being 1.2 mm. Upper margin sharp over its entire length. Immediately adjoining the upper margin on the inner surface are several, probably 11, small, round hair pits, average distance from pit to pit 1.02 mm. Immediately adjoining the upper margin on the outer surface are 5 oblong pits that are as an average 2.33 mm. apart.

Dactylus missing and fixed finger broken near the base. Dactylus apparently was much heavier than the fixed finger. Interdigital sinus rounded and broad.

Dimensions.—Monotype, left manus: length up to interdigital sinus, 12

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19 Lowe, E. N., Mississippi, its geology, geography, soil, and mineral resources: Miss. Geol. Surv., Bull. **12**:76-78, 1915; and Bull. **14**:77-79, 1919. The name Enterprise is preoccupied.

20 Cooke, C. W., Correlation of the Eocene formations in Mississippi and Alabama: U. S. Geol. Surv., Prof. Pap. **140**:135, 1926.

mm.; height at proximal end, 12.1 mm.; height at distal end, 10.4 mm.; greatest thickness, 4.7 mm.

Type locality.—On right bank of Chickasawhay River, 0.3 mile below the steel bridge at Enterprise, Clarke County, Mississippi.

Horizon.—Middle Eocene, lower Claiborne group, Enterprise glauconite marl at the base of the Winona formation.

Type.—Monotype in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

Callianassa gamma sp. nov.

Description of holotype, left manus.—The manus is one-fourth longer than high. Proximal end makes a right angle with both, upper and lower, margins. Upper margin straight for the proximal half of length; farther on gently descending and rising again to form a slight hump at the distal end. This hump is very little lower than the proximal half of the upper margin. There is a small, inconspicuous, rounded lobe at the proximal upper corner. Lower margin slightly sigmoidal in outline, in general ascending distally, and making proximally a fair-sized rounded lobe which is produced backward very little more than the upper lobe. Outer surface evenly convex from top to bottom. Inner surface nearly as much convex as outer surface. Inner surface has a slight concavity in the distal part, one-fourth of the height of the manus removed from the lower margin. Both surfaces subparallel from front to back, the outer a little convex, the inner nearly straight. Inner surface smooth and free of tubercles. Outer surface smooth except for the low place near the interdigital sinus. This place is occupied by about 40 crowded, low, small, rounded tubercles. Lower margin of manus defined by a fine, sharply raised ridge that is smooth to the outer surface and serrate to the inner surface. The ridge disappears proximally at the lower proximal corner lobe. Serration of the ridge is produced by deeply set, round to slightly oblong, pits. There are 17 such pits and interposed serrae preserved, their average being 0.56 mm. In the groove that separates the marginal ridge from the outer surface there are some small, round hair pits. Their number is probably 7 and their average distance 1.2 mm. Upper margin sharp along the proximal half of its length, bluntly rounded along the distal end. Immediately adjoining the upper margin there are on the outer surface three small, round hair pits, as an average 4.1 mm. apart. Immediately adjoining the upper margin on the inner surface there are 10 small, round pits that are more narrowly spaced at the proximal end, their average distance from each other being 1.7 mm. at the distal end and .97 mm. at the proximal end. Aside from the pits mentioned above there are 5 pits arranged around the edge of the orifice for the insertion of the dactylus. Of these five, three are on the inner surface and two on the outer surface. Fixed finger broken below the base. Interdigital sinus rounded but incomplete, probably wide originally.

Description of paratype 2, left manus.—This specimen had a complete fixed finger whose tip broke off before the specimen was photographed. Fixed finger slender, evenly curved, and gently tapering, rounded triangular in cross

section. Occludent surface smooth and toothless. Lower margin of fixed finger is rounded and the ridge of the lower margin of the manus disappears toward the base of the fixed finger. There are 8 pits on the inner surface of the fixed finger above the lower margin. These pits are a continuation of the row on the manus but become very widely spaced at the distal end. There are 3 widely spaced pits in the outer surface of the fixed finger in continuation of the corresponding row on the manus. There are 4 pits on the rounded ridge that extends from the interdigital sinus to the tip and separates the occludent from the outer surface. There is a solitary pit near the tip on the ridge that extends from the interdigital sinus to the tip and separates the occludent from the inner surface. The orifice for insertion of the dactylus indicates a rather bulky base of the dactylus.

Dimensions.—Holotype, left manus: length up to interdigital sinus, 13 mm.; height at proximal end, 10.7 mm.; height at distal end, 10 mm.; greatest thickness, 4.6 mm. Paratype, left manus: height at proximal end, 11 mm.; height at distal end, 10.7 mm.; greatest thickness, 4.7 mm.; length of fixed finger, 6.5 mm (1 mm. for worn tip).

Type locality.—On right bank of Chickasawhay River, 0.3 mile below the steel bridge at Enterprise, Clarke County, Mississippi.

Horizon.—Middle Eocene, lower Claiborne group, Enterprise glauconite marl at the base of the Winona formation.

Types.—Holotype and two paratypes in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

Callianassa wechesensis Stenzel

Callianassa wechesensis, H. B. Stenzel, Decapod crustaceans from the Middle Eocene of Texas, J. Paleont. 8(1):55, pl. 6, fig. 4a, 1934.

Description of figured specimen (1), left manus.—The manus is one-eighth longer than wide. Proximal end makes a right angle with both, upper and lower, margins. Upper margin gently curved and descending distally and making a small, inconspicuous, simple, rounded lobe at its proximal end. Lower margin ascending distally in a gently convex curve as a whole more convex than in *Callianassa gamma*. Margin has a slight concavity below the base of the fixed finger. At the proximal end of the lower margin there is a small, simple, rounded lobe, that is produced backward. This lower lobe is only very slightly larger than the upper lobe. Outer surface convex from top to bottom. Inner surface gently convex, but with a gently concave longitudinal dell, one-fourth to one-third of the height of the manus removed from the lower margin. Both surfaces subparallel from front to back and nearly straight. Inner surface bears tubercles only in one belt. This belt extends from the interdigital sinus through the concave dell, on its upper slope, to within 1.5 mm. from the manus-carpus joint. The tubercles of this belt are low, rounded, and scattered. They number about from 50 to 60. Outer surface bears merely a few low, rounded tubercles at the interdigital sinus. Lower margin of manus defined by a fine, sharply raised ridge that is smooth

to the outer surface and merely slightly denticulate to the inner surface. The ridge disappears proximally at the lower proximal corner lobe and distally near the base of the fixed finger. Denticulation of the ridge is produced by oblong to slit-like, forward pointing hair pits. There are 13 such pits and interposed denticulations preserved; originally they were probably about 17 in number. They are as an average 0.63 mm. apart. In the groove that separates the lower marginal ridge from the outer surface there are 4 to 9 indistinct pits preserved, their average distance being .56 mm. Upper margin of manus sharp for the proximal two-thirds of its length, bluntly rounded beyond. Hair pits to both sides of this margin probably like in preceding species but very indistinct due to the preservation of this specimen. Pits around orifice for the insertion of the dactylus same as in the last described species. Fixed finger essentially like in last species.

Description of specimen (2), right manus.—The two right manus specimens (2) and (3) are very similar to specimen (1) in many of their features. The semblance is such that the writer does not hesitate to assign them to the same species.

The manus of specimen (2) has the same shape as in the first. The ornamentation differs only in the following feature: There are no tubercles on the inner surface of the manus. The tubercles on the outer surface are like in specimen (1). The arrangement of the hair pits is also the same in all essential features although the number of pits is possibly not exactly the same. There are 22 pits along the lower margin of the manus on the inner surface and 5 in direct prolongation of this row on the fixed finger. The 22 pits have an average distance of 0.46 mm. between them. There are 5 pits along the lower margin of the manus on its outer surface and 1 pit in the prolongation of this row on the fixed finger. The 5 pits have an average distance of 1.73 mm. between them. There are 15 pits along the upper margin of the manus on its inner surface and their distance is 0.66 mm. There are 4 pits along the upper margin of the manus on its outer surface and they are 2.2 mm. apart as an average. The 5 pits around the orifice for the insertion of the dactylus are the same as in all other *Callianassa* specimens described here.

The fixed finger of this paratype differs from the fixed finger of specimen (1). It is much shorter and therefore stouter for its length and bears a low ridge-like tooth near the point on its outer upper margin. Along this same margin on the outer surface of the fixed finger there are 4 pits. The other pits of the fixed finger have been mentioned already.

Dimensions.—Figured specimen (1), left manus: length of manus up to interdigital sinus, 11.7 mm.; height at proximal end, 10.4 mm.; height at distal end, 9 mm.; greatest thickness, 4.3 mm.; length of fixed finger, 6.5 mm. Specimen (2), right manus: length of manus up to interdigital sinus, 10.3 mm.; height at proximal end, 8.7 mm.; height at distal end, 8 mm.; greatest thickness, 3.6 mm.; length of fixed finger, 4 mm.

Localities.—On outlier of Weches formation in Mrs. Louisa Gamble 176-acre tract, Joshua Townsend Survey, on Marquez-Flynn mail route, 5.75 miles east of Marquez, Leon County, Texas (type locality). On right bank of

Chickasawhay River, 0.3 mile below the steel bridge at Enterprise, Clarke County, Mississippi.

Horizon.—Middle Eocene, lower Claiborne group; in Texas in the Weches formation; in Mississippi in the Enterprise glauconite marl at base of Winona formation.

Types.—Three specimens in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

Callianassa sp.

Description of monotype, right dactylus.—Axis of dactylus gently convex to the outside, tip turned down at a right angle. Cross section oval. Outer surface gently convex from base to tip, inner surface gently concave from base to tip and gently convex from top to bottom. There is an obscure, blunt, longitudinal ridge through the middle of the inner surface. Occludent edge bears three teeth or tubercles. The first is the largest. It is high with nearly vertical sides and elongate in the direction of the occludent edge. The second tooth is the smallest and adjoins the first distally; it is bluntly conical. The third is intermediate in size, oblong in direction of the occludent edge, and steep. From this third tooth extends a sharp ridge in distal direction disappearing toward the tip. On the outer surface and along the proximal half of upper margin there are 4 round pits. A solitary pit in the center and two near the upper distal margin of the inside surface. There are 11 pits along the upper margin.

Dimensions.—Length, 16.2 mm.; greatest thickness near base, 4.0 mm.; height at and including the large tooth, 6.6 mm.

Locality.—On right bank of Chickasawhay River, 0.3 mile below the steel bridge at Enterprise, Clarke County, Mississippi.

Horizon.—Middle Eocene, lower Claiborne group, Enterprise glauconite marl at base of Winona formation.

Type.—The figured specimen is in the writer's collection at the Bureau of Economic Geology, Austin, Texas.

ACKNOWLEDGEMENTS

The writer wishes to express his gratitude to Mr. Merle C. Israelsky of Houston for the donation of the paratype of *Portunus vicksburgensis* and to Mr. L. Willis Clark of San Antonio for the donation of the holotype of *Callianassa burlesonensis*.

Mr. W. C. Spooner and Mr. Roy T. Hazzard of Shreveport, Louisiana, and Mr. B. W. Blanpied of Gulfport, Mississippi, gave valuable information concerning the locations and stratigraphy of fossil localities. The writer is very grateful of their cooperation.

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PLATE 14

FIGURES

1–2. *Lobonotus natchitochensis* sp. nov., internal mold of carapace, monotype, fig. 1 x1.88, fig. 2 x3.01 and illuminated from lower right to bring out the margin of the left eye.

3–4. *Lobonotus brazosensis* sp. nov., right manus and carpus, monotype, dorsal and frontal views, x3.06 and x3.15.

5–6. *Portunus*(?) *vicksburgensis* sp. nov., holotype, dorsal and frontal views, x1.09 and 1.03.

PLATE 15

FIGURES

1–2. *Callianassa alpha* sp. nov., left manus, holotype, inner and outer views.

3–3. *Callianassa beta* sp. nov., left manus, monotype, inner and outer views.

5–6. *Callianassa gamma* sp. nov., left manus, holotype, inner and outer views.

7–8. *Callianassa alpha* sp. nov., left manus, paratype, inner and outer views.

9–10. *Callianassa wechesensis* Stenzel, left manus, specimen 1, inner and outer views.

11–12. *Callianassa wechesensis* Stenzel, right manus, specimen 2, inner and outer views. All figures are x1.98.

PLATE 16

FIGURES

1–2. *Callianassa burlesonensis* sp. nov., right manus, paratype, outer and inner views, x 3.15 and 3.06.

3–4. *Callianassa burlesonensis* sp. nov., left manus, holotype, inner and outer views, x 3.15 and 3.06.

5. *Callianassa gamma* sp. nov., left manus, paratype 2, outer view, x 1.98.

6–7. *Callianassa* sp., right dactylus, outer and inner views. x 1.98.

PLATE 14

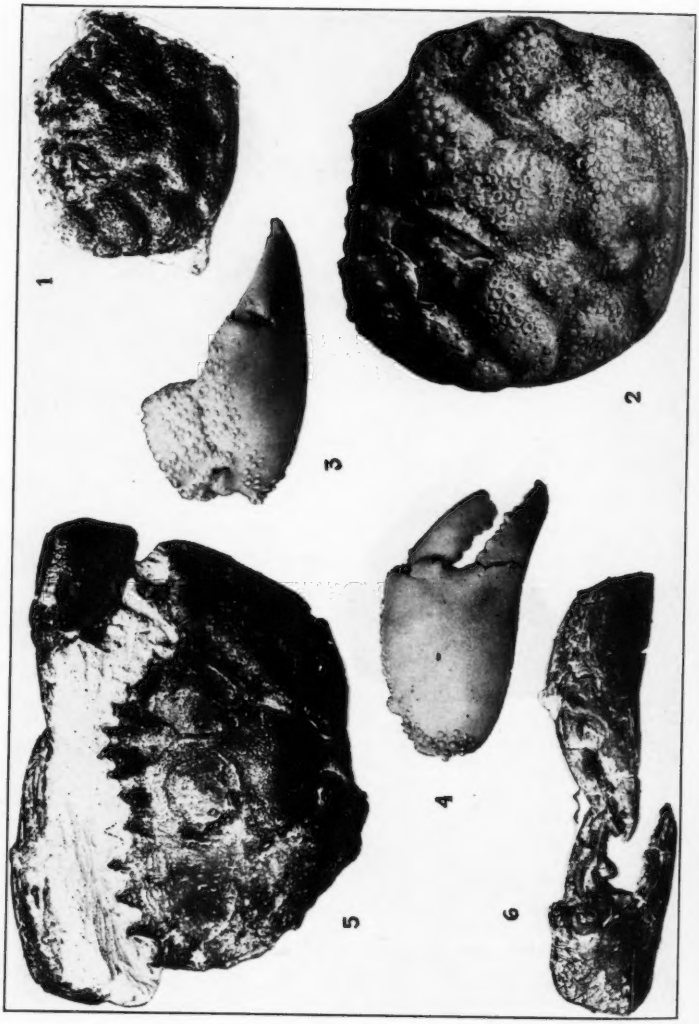


PLATE 15

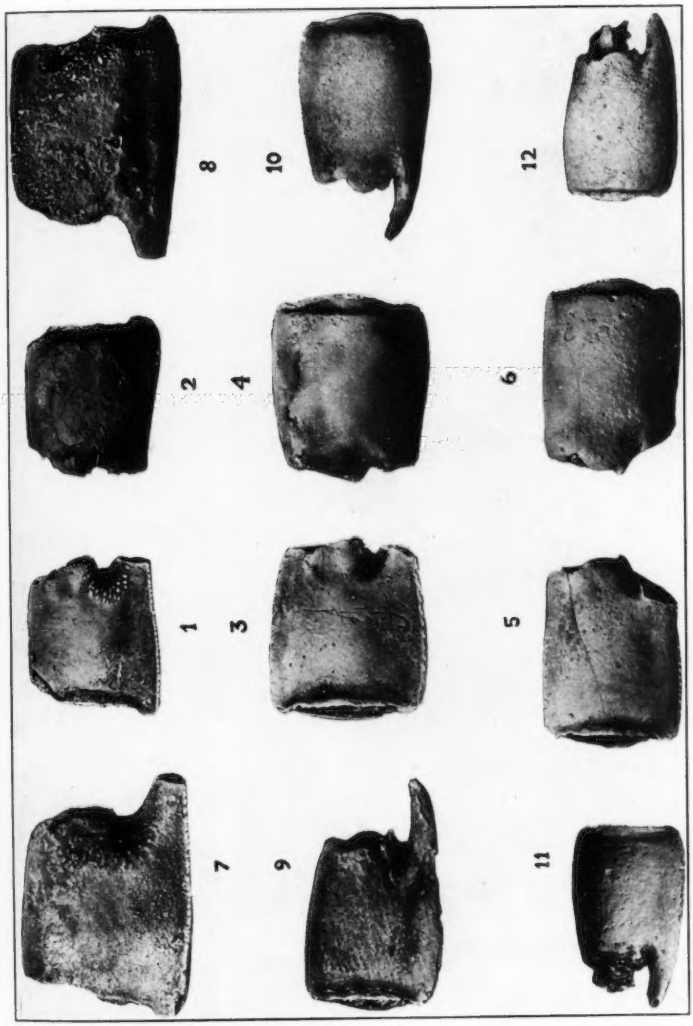


PLATE 16

A NEW AMMONITE GENUS FROM THE UPPER TRIASSIC OF CENTRAL OREGON

EDWARD THEODORE SCHENK

This new genus described from the Oregon Triassic is of special interest because it shows a remarkable external resemblance to *Haplopleuroceras* Buckman from the Middle Jurassic of England. This similarity was first pointed out by Professor S. W. Muller[1] of Stanford University. Later Dr. L. F. Spath[2] of the British Museum of Natural History independently came to the same conclusion. Both were kind enough to compare the material with specimens not available to the writer and both agreed that the form is new. The only Triassic genus which exhibits similar characters is found in the "Hallstätter Kalke"[3] of western Austria and in the "Tropites-Limestone"[4] of Byans, India. The ammonite fauna from the beds of the central Oregon locality[5] comprises at least ten genera and sixteen species, related to the Upper Karnic fauna of Brock Mountain, Shasta County, California.

Systematic Description

Class CEPHALOPODA

Order AMMONOIDEA

Suborder *Tropitidae* Mojsisovics

Genus **Tritropidoceras**[6] gen. nov.

Genotype.—Tritropidoceras packardi sp. nov.

Diagnosis of Genus.[7]—Form evolute, widely umbilicate, whorls slightly embracing. Width of volution almost equal to height. Surface with numerous nodose ribs which trend toward the aperture after crossing the ventral shoulder. Venter flattened with a high keel bounded by deep furrows on either side. Secondary keels present on the outer margins of the furrows. Septa weakly ammonitic with divided ventral lobe and with two laterals.

Affinities.—The genotype of *Tritropidoceras* appears to be most closely

1 Personal communication dated May 20, 1931.

2 Personal communication dated February 13, 1933.

3 Mojsisovics, E., Die Cephalopoden der Hallstätter Kalke. Abhandl. der k. k. Geologischen Reichsanstalt **6**(2), Wien, 1893.

4 Diener, Carl, Fauna of the Tropites-Limestone of Byans. Palaeontologia India, Ser. 15, **5**, Mem. 1, 1906.

5 Schenk, Edward T., Marine Upper Triassic of Central Oregon. Abstract, Proc. Geol. Soc. Amer. **1933**:388, June, 1934.

6 τρεῖς, τρία, three; τρόπις, τρόπιδος, keel; κέρας, horn.

7 This diagnosis is based upon the species *Tritropidoceras packardi* Schenk, which is the only known species of this genus.

allied to *Tropiceltites areititiformis* Mojsisovics.[8] The exact relationship cannot be definitely stated until the characters of the sutures are observed in specimens of the European species. Furthermore, all the European species related to *T. areititiformis* are of small diameter and appear to lack distinct nodes. In the description of *Tropiceltites,* Mojsisovics[9] states that the genus is characterized by lobes which are, "entire, unserrated (Clydonitic)." In short, the taxonomic position of *Tropiceltites areititiformis* Mojsisovics is uncertain and needs critical revision.

The genus *Tritropidoceras* is placed in the family *Tropitidae* Mojsisovics because the young stages of *T. packardi* have, in their ontogenetic development, characters which resemble comparable stages in *Tropites subbullatus* (Hauer)[10] genotype of *Tropites,* which in turn is the type genus of the *Tropitidae.*

Tritropidoceras packardi[11] Schenk sp. nov.

Plate 17, Figs. 1-16.

Description.—Shell evolute, slightly embracing and little impressed by the inner volutions. Widely umbilicate. Whorl hexagonal in cross-section, sides slightly convergent ventrally with angular ventral and umbilical shoulders. Venter broad, flattened with high sharp keel which may be slightly crenulated. Keel bounded by furrows which rise to secondary keels on their outer margins. Surface with numerous sharp distinct ribs which extend straight up the sides to the ventral shoulders, turn abruptly forward forming a node, and continue to the secondary keels bordering the furrows. Ribs occasionally bifurcate forming a node at the place of branching. Each rib on a mature specimen has four distinct nodes regularly arranged, one on the ventral shoulder, two on the flanks, and one on the umbilical shoulder. Nodes increase in size as the shell grows larger. Body chamber long, at least one volution or more. Aperture not observed. Septa weakly ammonitic. The external lobe is divided by a deep rather broad siphonal notch. The first lateral saddle is broad, shallow, and weakly but distinctly serrated. The second saddle is smooth.

Dimensions of holotype
Pl. 17, Figs. 1, 2, 13.

	Millimeters
Diameter	59.
Height of last whorl	17.
Height of last whorl from preceding	16.
Width of last whorl	16.5
Involution	1.
Width of umbilicus	28.

8 Mojsisovics, *Op. cit.*, p. 384, pl. 130, figs. 39, 40.
9 Mojsisovics, *Op. cit.*, p. 369.

10 Smith, J. P., Upper triassic marine invertebrate faunas of North America. U. S. Geol. Survey Prof. Paper **127**:29, pl. 34, figs. 1-14, pl. 79, figs. 1-10, 1927.

11 This species is named in honor of Professor E. L. Packard of Oregon State College in recognition of his contributions to the knowledge of geology and paleontology of central Oregon.

Dimensions of paratype, Condon Museum No. 350.
Pl. 17, Figs. 3, 4, 16a.

	Millimeters
Diameter	46.
Height of last whorl	14.
Height of last whorl from preceding	13.
Width of last whorl	14.
Involution	1.
Width of umbilicus	22.

The foregoing description and dimensions apply to the mature shell. The inner coils up to a diameter 1.5 mm. (Plate 17, Figs. 11, 12) are involute, low-whorled, broad, and widely umbilicate. The umbilical shoulders are sharp and without nodes. At a diameter of 3 mm. (Figs. 9, 10, 15) the whorls become more robust; a weak keel appears and weak ribs begin to develop on the umbilical shoulders. After a diameter of 6 mm. (Figs. 5, 6, 7, 8, 14) little change occurs in the shape of the whorls. Distinct nodes do not appear until the shell reaches a diameter of about 25 mm. In the gerontic stage the nodes become larger and the ribs are spaced farther apart.

Dimensions of young stages.

	Millimeters			
Diameter	11.	6.	3.	1.5
Height of last whorl	3.	2.	1.08	.55
Height of last whorl from preceding	2.5	1.68	.8	.42
Width of last whorl	4.	2.5	1.5	1.03
Involution	.5	.32	.28	.13
Width of umbilicus	5.7	3.	1.2	.67

Affinities.—*Tropiceltites arietitoides* Diener[12] from the "Tropites-Limestone" of Byans, India, appears to be the most closely allied species to *Tritropidoceras packardi*. Diener placed his species in the genus *Tropiceltites* Mojsisovics in spite of the fact that it definitely has serrated septa which automatically removes it from Mojsisovics's genus as defined. It is likely that when the suture of the Indian species is better known it will fall in the genus *Tritropidoceras* instead of *Tropiceltites*. However, *arietitoides* lacks the well-developed nodes of *Tritropidoceras packardi* and has wider intercostal spaces as well as spiral striae intersecting the ribs.

Holotype.—Stanford Univ. Paleo. Type Coll. No. 5899, Stanford University, Calif. Pl. 17, Figs. 1, 2, 13.

Paratypes.—Stanford Univ. Paleo. Type Coll. No. 5900. Pl. 17, Figs. 5-12, 14, 15, 16b, c, d, e, f. Condon Museum No. 350. University of Oregon, Eugene, Oregon. Pl. 17, Figs. 3. 4, 16a. U. S. National Museum No.75482, Washington, D. C. California Academy of Science Nos. 4698, 4698a. San Francisco, Calif. British Museum of Natural History No. C. 35932, London, England.

Type Locality.—The types of *Tritropidoceras packardi* are from Grant

12 Diener, *Op. cit.*, p. 156, pl. 3, figs. 12a, b.

County, Oregon, ten miles east of the town of Suplee and one and one-half miles south of the Bailey Ranch, longitude 119° 30′, latitude 44° 5′. This locality is in the southwest quarter of section 29, T. 17 S., R. 27 E., along the east side of an unimproved road. Less than one hundred yards south of this locality, Howard Gulch joins the valley of Brisbois Creek. Ten specimens were collected by the writer in black bituminous limestone. Two of them are remarkably well preserved and a few show the original shell.

Geologic Age.—Associated with *Tritropidoceras packardi* are such genera as *Tropites, Discotropites, Paratropites, Juvavites, Homerites,* and *Klamathites,* an assemblage, as previously stated, typical of the Upper Karnic, *Juvavites* subzone of Brock Mountain, Shasta County, California.

STANFORD UNIVERSITY,
CALIFORNIA

PLATE 17

FIGURES

1, 2. *Tritropidoceras packardi* Schenk, sp. nov. Holotype. Side and front views. Stanford Univ. Paleo. Type Coll. No. 5899. x1.

3, 4. Side and front views of paratype, Condon Museum, University of Oregon. No. 350. x1.

5, 6. Side and rear views of young stage; diameter 11 mm. Stanford Univ. Paleo. Type Coll. No.. 5900. x3.

7, 8. Side and rear views of young stage; diameter 6 mm. Same specimen as figures 5, 6. x3.

9, 10. Side and front views of young stage; diameter 3mm. Same specimen as figures 5, 6. x5.

11, 12. Side and front views of young stage; diameter 1.5 mm. Same specimen as figures 5, 6. x11.3.

13. Cross-section of last whorl of fig. 1. x1.6.

14. Cross-section of last whorl of fig. 7. x3.

15. Cross-section of last whorl of fig. 9. x4.5.

16a. Last suture of specimen shown in fig. 7. x2.6.

b. Suture of young stage; diameter 18 mm. x5.

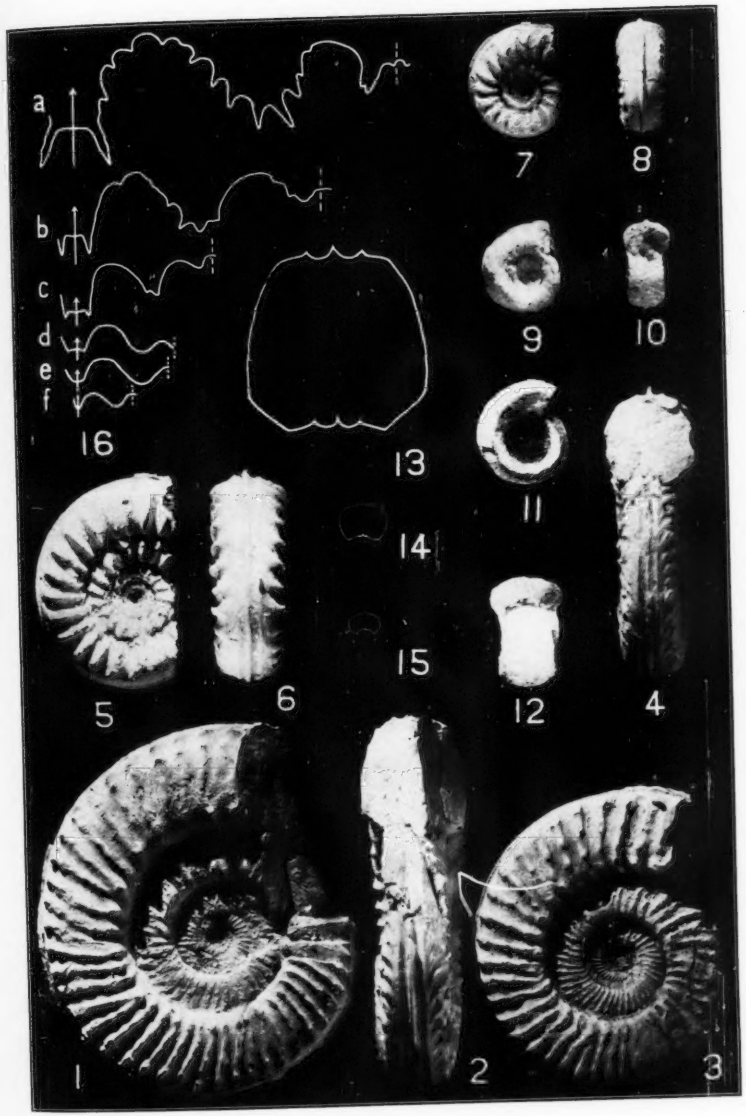
c. Suture of young stage; diameter 11 mm. x7.

d. Suture of young stage; diameter 6 mm. x8.

e. Suture of young stage; diameter 3 mm. x14.

f. Suture of young stage; diameter 1.5 mm. x12.

PLATE 17



LOCOMOTIVE HABITS OF SOME TRILOBITES

DAVID M. DELO

Many writers on the trilobites have attempted to explain their life habits by comparison of their skeletons with those of modern marine arthropods, particularly with those of Limulus and the isopods. During a recent systematic study of the *Phacopidacea*, the writer has had occasion to examine critically some of the previous conclusions regarding the life habits of the trilobites. He believes that the fundamental principle actuating these comparisons is sound, but that too literal an interpretation has been made of the available data.

The writer is indebted to Professor P. E. Raymond and to Dr. Henry Stetson of the Museum of Comparative Zoology for many stimulating suggestions and much careful criticism of his conclusions.

The habits of *Limulus*, the common horse-shoe crab have been evoked for trilobites such as *Dalmanites* with a conspicuous caudal spine and flattened body form. *Limulus* is referred to as a burrowing creature, and much has been written of its use of the long spike-like telson in forcing its way through the bottom mud. The eyes are located near the center of the convex carapace, which is large enough to cover completely the ventral appendages. *Limulus* is not a true burrower, however. It plows its way through the soft bottom deposits but usually only to a depth of an inch or so, the upper portion of the carapace seldom being covered. Cases of *Limulus* burrowing completely beneath the surface are known, but the writer is not convinced that this is habitual practice. His scepticism is caused by the finding of large numbers of *Limulus*, along the New England coast, to which were attached sessile gastropods, barnacles, and mussels. It seems reasonable to suppose that these animals could not have adhered to the test and there attained considerable size if the *Limulus* habitually burrowed beneath the surface.

Limulus also swims slowly near the bottom. The ventral appendages furnish the propulsive force, and the direction of movement is forward.

The isopods also show affinities to the trilobites in general body form and habits. *Bathynomus*, the largest of the isopods, is a benthonic creature living in depths of 750 to 950 fathoms. It has a flattened body much like that of *Dalmanites*. The telson is large, flat, and denticulated behind with a terminal point and five pairs of lateral denticles. The eyes are located at the anterior edge of the cephalon, and are directed forward and downward. They are relatively as large as those of *Dalmanites*. Many of the ventral appendages are highly specialized.

The marine lobsters and freshwater crayfish may furnish some analogies to the trilobites. These creatures can move backward very quickly for a few feet by means of a downward and forward flip of their powerful telson. The large claws act as a rudder, directing their backward movement. They also

crawl slowly over the bottom, and swim forward by means of their abdominal appendages.

A third group of crustaceans, the free swimming shrimps, may also furnish clues to the habits of the trilobites. Some species range throughout great vertical depths, and others are restricted to certain depth zones, some shallow, and some very deep. There is apparently no general relationship between body form and depth of the living zone. The body is very narrow, and they swim forward by means of the ventral appendages. They also dart backward for a short distance in the same fashion as do the lobsters.

For purposes of comparison with these modern forms, the phacopid trilobites may be divided into two general groups, on the basis of body pattern. The one, with broad flat body and large cephalon and pygidium, is represented by the genus *Dalmanites*, found commonly in rocks of Silurian age; the other, convex, compact, with small cephalon and pygidium, is represented by the genus *Phacops*, abundant in the Devonian. There was probably little difference in their appendages, except for a reduction in the anterior cephalic appendages of *Phacops*.

Dollo (1910: 408), Staff and Reck (1911: 130) and Raymond (1920: 72, 100), thought that large flat trilobites propelled themselves backward by a flap of the large pygidium. Raymond also suggested that an up and down motion of the tail of *Isotelus* (Ordovician) might have produced a forward motion (loc. cit.: 99). Finch (1904: 181) believed that *Vodgesia vigilans* buried all of its body but the eyes in the mud, and there lay in wait for its prey. He thus inferred a benthonic habit for this form. His theory was based on the finding of specimens buried more or less vertically in the mud, but with the cephalon in an horizontal position.

The writer is of the opinion that Dollo and other writers have failed to refine their application of the analogies between the trilobites and modern crustacea sufficiently, particularly in reference to *Dalmanites* and related forms. There are two points of particular interest: first, the large projecting, conical eyes on the flattened cephalon; second: the large size and mucronate nature of the pygidium.

To cite an extreme case, it is hardly reasonable to think of a form like *Dalmanites longicaudatus* (Murchison) or *Probolium nasutus* (Conrad) darting suddenly away from a source of danger by a sudden flip of its large pygidium. Both these species possess a caudal spine as long or longer than the remainder of the pygidium. A powerful flap while the animal was feeding or quietly resting on the bottom would doubtless have imbedded the long slender spike in the mud, or have broken it.

Nor can *Dalmanites* be thought of as a sub-surface burrowing form if one considers carefully the nature of the eyes. These are large, highly protuberant, and doubtless were easily injured. Their large size suggests that they have been used in regions of moderate illumination. But the shape (a truncated semi-cone), is by no means one adapted to slipping easily through the mud.

It is plausible to suppose, however, that *Damalnites* may have burrowed in much the same manner as is habitual with *Limulus*. The broad cephalic

brim, low glabella, and long genal spines, suggest that it may have progressed partially buried in the soft mud when feeding or searching for food, but with the elevated eyes protruding above the surface. The appendages (as figured for *Asteropyge* by Broili, 1930: 293-300, 2 text figs.) were relatively as large as those of *Limuusl*, and were the means of propulsion as in the latter.

The long, slender, forked anterior cephalic process of some Dalmanitid forms (*Probolium nasutus* for example) suggests that they did not force their way through any but the softest mud, as the process must have been easily broken.

Thus the body form, nature and position of the eyes, nature of the pygidium, and inferred nature of the appendages, suggest that *Dalmanites* had habits similar to those of the modern *Limulus* or *Bathynomus*. If the pygidium were used in an undulatory fashion for forward progress, as suggested by Raymond for *Isotelus*, it must have taken place while the animal was sculling along above the bottom. Use of the pygidium from a standing start on the bottom, as is the habit of the modern lobsters, appears to have been out of the question. This interpretation relegates the pygidium to a position of secondary importance as a swimming organ in *Dalmanites* and other genera of similar body form.

The group represented by *Phacops*, with compact head, small pygidium, and convex body, are believed to have had somewhat similar habits. The head was blunt, and can by no means be construed as that of a burrowing creature. The pygidium was small, consisting of only a few segments, and rounded behind. Although not comparable in efficiency to the telson of the shrimp or lobster when used as a swimming agent, yet an organ of this nature was doubtless effective for short, rapid, backward darting movements. The large heavy head of *Phacops* may have assisted in directing its backward course for a few feet.

The large-tailed trilobites probably had no means of maintaining a straight backward course. As indicated by Raymond (loc. cit.), a sudden flip of the pygidium which formed so large a portion of the entire body might have propelled the animal backward in almost any direction. This is not the case in *Phacops* and similar forms, for the small pygidium needed only to be flexed to give a backward impulse effective for a short distance.

The appendages of *Phacops* were relatively as large as those of Dalmanitid trilobites, and there is no reason to believe that they could not have been used for slow progress forward through the water.

The position of the eyes in many species of *Phacops* and related genera forms a powerful argument against the supposition that they were habitual burrowers. The species from strata of Upper Devonian age in Europe have eyes which are located well forward on the cheeks, and which in some cases are directed almost straight forward. The facets were greatly reduced in number, and individually enlarged, being thus susceptible to injury if the animal burrowed beneath the surface.

It is not to be inferred from the above that the present writer believes any

of the Phacopidacea to have been other than benthonic in their living habits. All the available evidence appears to indicate that they crawled slowly across the bottom, perhaps burrowing partially in search of food. They also appear to have possessed the power of swimming in a rather inefficient manner by means of their ventral appendages, but probably never rose more than a few feet above the bottom.

The role of the pygidium as an aid in swimming should be considered as of secondary importance in the dalmanitid trilobites, although this was probably not true of *Phacops* and its immediate congeners. And finally, there appears to be no valid evidence, either direct or inferred, to indicate that any of the Phacopidacea were true burrowing creatures.

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NITROCELLULOSE SECTIONS OF FOSSILS AND ROCKS[1]

MILDRED ADAMS FENTON

During a study of fossil corals at the University of Chicago, under the auspices of the Elizabeth Thompson Science Fund, difficulties were encountered in the preparation of thin sections from rocks, since many specimens crumbled under the vibration of the saw. Dr. A. S. Romer suggested that the peel method devised by paleobotanists might be successfully applied to corals since one of his students, Mrs. E. Hough, was using it to make serial sections of a calcified skull. The first experiments with collodion, however, were unsuccessful; highly wrinkled films with bubbles and insufficient rock material on the film being defects persistently encountered.

The nitrocellulose solution developed by Dr. Roy Graham[2] for paleobotanical material then was tried and satisfactory sections were obtained. His method has since been used by Mrs. Hough on vertebrate fossils and by Mr. J. E. Appel[3] in studies of noncalcareous sediments.

The Graham method, as applied to the calcareous specimens, especially corals, involves the following steps:

1. Smooth the surface with fine carborundum (600 F) on a glass plate.

2. Etch in a 5 per cent solution of commercial HCl until the characters are clearly demarked; from 30-60 seconds. (Full strength commercial HF was used by Appel on silicified rock specimens). Partially silicified specimens of corals treated with HCl gave satisfactory sections; see figure 1.

3. Wash without touching the etched surface, by dipping in water. (Water may be allowed to flow *gently* over large surfaces.)

4. Allow to dry and place so the surface is horizontal, using a sand box or plastilene.

5. Apply enough of the following solution to cover the surface, spreading it with a glass rod (if bubbles appear remove them with a scalpel):
   20 g. 15/20 second nitrocellulose (guncotton). Commercial preparations such as Parlodion may be used but are needlessly expensive.

   200 cc. Butyl acetate, commercial.
   1 cc. Tri-cresyl phosphate.

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1 Presented before the Paleontological Society December 30, 1933.

2 Graham, Roy, Preparation of Palaeobotanical Sections by the Peel Method. Stain Technology, **8**:65-68, 1933.

3 Appel, J. E., A film method for studying textures. Econ. Geol. **28**(4):383-388, 1933.

10-20 cc. Toluene or xylol[4] if a very easily removable film is desired. Keep solution in glass stoppered bottle with wide mouth.

6. Allow solution to dry 12 to 72 hours in ordinary room temperature; the longer the film is allowed to remain on the rock surface the less it will shrink upon removal. Two or three days, however, are suffiicent for even large, thick sections. If the film is too thin more of the nitrocellulose solution may be added and again allowed to dry.

7. Loosen the film from the surface with a razor blade or scalpel and peel.

Sections may be filed in envelopes or mounted dry between glass—the so-called air mounts. For filing, the envelopes are the simpler and more economical of space, a piece of cardboard slipped in with the section providing adequate protection. If transparent envelopes, such as are sold by philatelic dealers, are used their card also may bear the label.

In photography, these nitrocellulose films may be used as an ordinary negative in an enlarger using the transmitted light. Negative for the illustration in this paper was thus made, the enlarger being an ordinary stereopticon fitted with an anastigmat lens taken from a camera. For such use the sections are placed between two hinged cover glasses, being tipped to one of them by means of small dots of glue applied to their edges on the film side. A process film or lantern slide plate, occupying the position of the enlarging paper, furnishes a negative which in turn may be enlarged or printed by contact.

Film sections prepared by the Graham method have several advantages over rock sections:

1. Ease of preparation. They require, at most, one-half as much sawing; in the preparation of closely-spaced serial sections sawing may be dispensed with entirely. There is similar economy in grinding—one face, not two, for each section taken—and freedom from the labor of mounting in balsam.

2. Minimum wastage. As many as 16 sections can be made from the rock wasted in sawing a single slice; 8-15 more can be made from the equivalent of that slice itself. If so many sections are not needed, the rock destroyed by slicing can be preserved for future study. Large sections can be prepared with ease from polished surfaces (one measuring 126 x 152 mm. has been prepared) at the rate of 6-8 per mm. of rock used.

This economy of material and freedom from breakage makes it possible to take sections from types without injury to them, or to make duplicate sections of types for distribution to museums and specialists. In a study now in progress, we are sending out three or more sections of each important type, with duplicates for future needs.

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4 This was not used in preparing coral sections though it might be desirable if specimens were set in plaster-of-Paris.

3. Ease of handling. Film sections being non-breakable, they require neither the care in handling nor in storage demanded by rock sections on glass.

4. Ease in photography. This has been discussed. It is important, also, that with experience sections are made which are essentially uniform in thickness and opacity, so that several may be photographed at a single exposure—something almost impossible with rock sections.

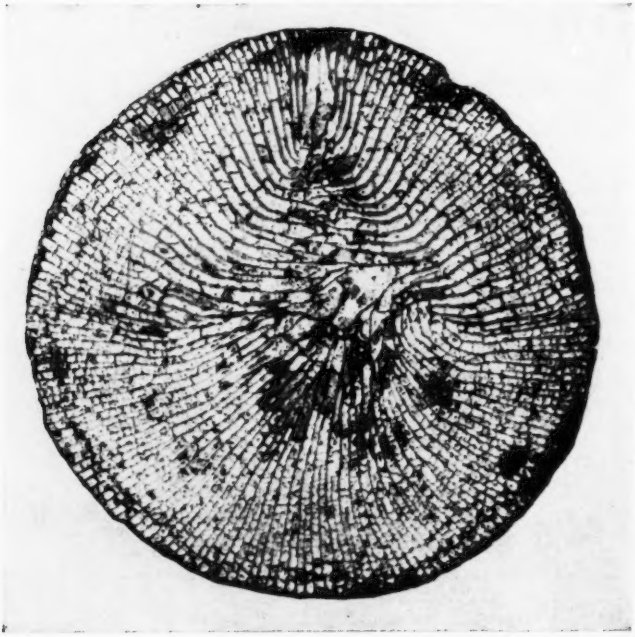

Fig. 1. "*Cyathophyllum*" *validum* Hall. Transverse section of a partly silicified specimen. The siliceous areas consist of gray patches below the center and black peripheral masses. x 1.5.

There are disadvantages, of course. Some specimens give such slight contrast that satisfactory prints can be produced only by intensification of negatives. Very fine structures may be lost entirely—the spines on septa of small species of *Pleurodictyum*, for instance—so that rock sections must be made. But for most corals, brachiopods, oölites, flat-pebble conglomerates and banded, somewhat shaly limestones and calcareous dolomites the method has proved highly satisfactory.

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AN OZARK VARIETY OF PHLOX PILOSA*

EDGAR T. WHERRY

Some ten years ago the writer undertook a taxonomic study of the genus *Phlox*, starting with the species native east of the Mississippi River. The fifteen species distinguishable there have been discussed, a few at a time, in a series of articles in Bartonia (1929-1935). Of these, seven also cross that river and range into the Ozarkian Highlands of Missouri and Arkansas: *P. bifida* Beck, *P. divaricata* L., *P. pilosa* L., *P. glaberrima* L., *P. maculata* L., *P. amplifolia* Britton, and *P. paniculata* L. So far as can be ascertained from material at hand, all but one of these are represented in the Ozark region by varieties also known further east, although a more detailed study of this point might well be made by someone who can carry on field comparison of the

Fig. 1. *Phlox pilosa ozarkana* north of Shreveport, Caddo parish, Louisiana. Photograph by Edgar T. Wherry, April 20, 1934.

* Contribution from the Botanical Laboratory and Morris Arboretum of the University of Pennsylvania. A trip to the Ozark region in April 1934 to obtain field data on the plant here described was made possible by a grant from the Board of Graduate Education and Research.

plants of the respective regions. The one exception is *Phlox pilosa*, which as previously noted (1931, p. 46) here presents a well-marked local variety. This may be known as:

Phlox pilosa ozarkana var. nov.

OZARK PHLOX

Plant a glandular-pubescent or rarely glabrate perennial with short thickish rootstocks; stems single or often several from one crown, simple or somewhat branched, thickish, averaging 40 cm. tall, with 6 to 10 nodes up to the inflorescence; leaves opposite or the uppermost alternate, thinnish, acute to acuminate, passing from linear at the base of the stem to oblong-lanceolate or broadly ovate and cordate-clasping, on the average 60 mm. long and 15 mm. wide, just below the inflorescence; flowers borne in small cymes grouped in a rather lax corymb or panicle; bracts conspicuous, the lowermost similar to the upper leaves; sepals narrow, 9.5 to 13.5 mm. long, united into a tube for about 1/3 their length, and tipped with an awn 1 to 2 mm. long; corolla-tube 12 to 16 mm. long, usually pubescent, the lobes obovate, about 12 by 8 mm., terminally obtuse or somewhat apiculate; corolla-color phlox-purple throughout some colonies, near-white throughout others, both extremes together with intermediate hues appearing in still other colonies; eye often pale, and marked with 2-3 conspicuous striae at the base of each lobe, ranging in hue from tyrian rose through purple to violet; stamens rather short, the anther-tips lying below the corolla-tube orifice at average depths of 2, 2.5, 4, 6, and 7 mm. respectively; styles short and about half-united, the compound style averaging 1 mm. in length, and the stigmas slightly longer or rarely shorter.

Caulibus crassiusculis, simplicibus vel pauciramosis, glandulosis vel rarius glabris; foliis superioribus oblongo-lanceolatis vel ovatis, basi cordiformi semiamplexicaulibus; sepalis angustis, longe aristatis, circa usque tertiam partem longitudinis tubuliformi-connatis.

Type specimen: in herbarium Academy of Natural Sciences of Philadelphia, collected by Edgar T. Wherry 2 miles south of Mountainburg, Crawford County, Arkansas, April 29, 1934.

The usual habitat of this plant is in humus-rich soil on a wooded hillside, the reaction being low subacid — active acidity 10 to 30, pH 6.0 to 5.5. Flowering begins in mid-Spring and continues into early Summer. The flowers are often sweet-scented, with a fragrance resembling that of jasmine, and are apparently cross-pollinated by moths as well as butterflies.

Phlox pilosa ozarkana is known to have been collected in the following states and counties:

ARKANSAS: Benton, Carroll, Crawford, Logan, Lonoke, Madison, Nevada, Newton, Pope, Sebastian, Washington, and Yell. LOUISIANA: Caddo, an extension well out into the Coastal Plain. MISSOURI: Barry, Carter, Iron, Jefferson, McDonald, and St. Louis. OKLAHOMA: Cleveland, Le Flore, Mc Curtain, and Muskogee.

On the accompanying map the boundaries of the Ozark, Ouachita, and Coastal Plain physiographic provinces are shown by heavy lines. Solid dots

represent county records of typical material, open circles a few localities of intermediates between this and the widespread variety (*virens*).

At first sight specimens of this *Phlox* look decidedly different from the widespread phase of *P. pilosa*. The frequent presence of glandular pubescence well down the stem and leaves, the thickish and often branched stem, the thinner and broader leaves and the long narrow calyx-lobes give it a unique aspect. These are, however, all rather superficial and non-fundamental characters, and moreover both within and around the margins of the Ozark region

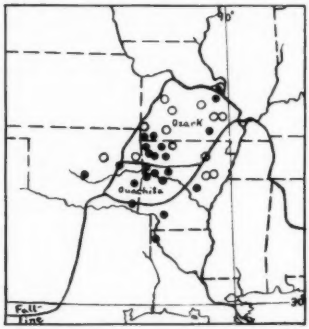

Fig. 2. Distribution of *Phlox pilosa ozarkana*.

intergradations with ordinary *P. pilosa virens* are of frequent occurrence. Were an attempt made to draw up a dichotomous key for separating them, every single characterization would have to be restricted by introducing "normally," "usually," "except in intermediates," etc. They may be contrasted, in geographic relationship, as follows:

Phlox pilosa ozarkana:

Stem tending to be thickish, branched, and glandular, and upper leaves to be glandular, ovate and cordate; sepals decidedly narrow and long-awned; range chiefly Ozarkian.

Phlox pilosa virens:

Stem tending to be slender, unbranched, and eglandular, and upper leaves to be eglandular, lanceolate and truncate; sepals moderately narrow and long-awned; range chiefly eastern.

Specimens of the new variety have been found in some herbaria labelled *Phlox divaricata*, and it does agree with that in the thickish glandular stem, but there the resemblance ends: *P. divaricata* has much better developed persistent sterile shoots, fewer stem-nodes, shorter leaves which do not become markedly wider upward, broader sepals, consistently glabrous corolla-tube, and more violet corolla-color.

The distribution of its several varieties points to the Ozark region having been the ancestral home of *Phlox pilosa*, and except for its narrow sepals,

variety *ozarkana* might be taken to be the ancestral phase of the species. As however, foliaceous sepals seem likely to be a primitive character, and several of the outlying varieties have this character well-developed, it is considered probable that the real ancestor of the group has become extinct.

A more northern variety, *fulgida*, and two more eastern ones, *amplexicaulis* and *detonsa*, have been discussed in the papers already cited. Westward from Ozark region, there appear to be still other varieties developed. One resembling the widespread variety *virens*, except in having more numerous nodes and so looking much more leafy, barely enters the western borders of this region, but is apparently more widespread in Texas, where it passes into the plant named *Phlox aspera* by E. Nelson. While I have obtained a slight field acquaintance with these more western varieties, it is not my intention to describe them, because that can be better done by someone who can collect them more extensively. At present, Miss Eula Whitehouse is engaged in their study.

Thanks are hereby extended to Miss Caroline Dormon for guidance to localities of this *Phlox* in Caddo Parish, Louisiana, and to Professor Dwight M. Moore of the University of Arkansas for similar aid in locating a number of stations in that State.

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NOTES ON FOREST TYPES OF NORTHWESTERN ARKANSAS *

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Northwestern Arkansas is near the western edge of the Oak-Hickory forest of the central United States (Shantz and Zon, 1924) (Weaver and Clements, 1929) and within the scope of the "Ozark Area, Alleghanian-Ozark District, Piedmont - Appalachian - Ozark Plateau - Mountain Region (Harshberger, 1911). Many features of the forests of this general region have been described by Palmer (1921), and by Bruner (1931).

Climatic and soil conditions tolerable to most species of the Oak-Hickory forest persist 100 miles farther west. However, instead of homogenous forest in this strip (75 miles on each side of the Oklahoma-Arkansas line) there is a steadily diminishing number of the more mesophytic species and an increase in the less mesophytic ones. Obviously it is near the transition zone between mesophytic forest and the savanna-like association of middle Oklahoma (Bruner, 1931). According to Harshberger its forests are largely made up of species that have migrated from the east and southeast. Possibly the apparent gradient character of the present day flora of the region is determined both by a gradient in climate and soil and by the fact that the westward post-glacial migration of eastern and southeastern species is incomplete. Except in xero-mesophytic situations neither the pioneer forest species nor those of the climax forest are the dominant ones. Broadly speaking a sub-climax forest type of diversified nature seems to be characteristic of the region.

Description of Forest Types

Although the general character of this forest may be considered sub-climax it is obvious that all grades of forest from pioneer to near-climax occur. As would be expected the least mesophytic situations are today occupied by the pioneers, and the more mesophytic situations, aside from the floodplains, by sub-climax and climax forest species. In the following description of the forest types present they will be listed in their apparent order of least to greatest mesophytism.

1. The Red Cedar Association

Notably on bluffs, hills and in rocky glades near the White river, *Juniperus virginiana*[1] and to lesser extent *Juniperus ashei* (Bucholz, 1930) may comprise pure or almost pure stands. These are similar to the "cedar glades" of

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1 Nomenclature after Sudworth's "Check list of the forest trees of the United States, etc."

middle Tennessee described by Harper (1926). There is some evidence that such are associated with limestone soils and outcroppings. *Quercus stellata, Q. marilandica, Ulmus alata* and *Bumelia lanugmosa* are important associates of these species in such situations. Commonly this association will occupy the south facing slope of ridges whose north facing slope is occupied by the scrub oak, winged elm, hickory, the black oak, hickory, or the white oak, red maple, hard maple associations.

2. The Scrub Oak, Winged Elm, Hickory Association

The *Quercus stellata, Q. marilandica, Ulmus alata, Hicoria buckleyi arkansana* association is one of the most common and extensive types of the region. It is the forest cover of the thin-soiled, rocky hills, south slopes and tops of ridges, and in general where drainage is excessive. *Quercus stellata* and *Q. marilandica*, singly or together, may make up pure oak stands, or may be associated with various proportions of the other species of the association. The following additional species of this association are listed in apparent order of diminishing importance: *Diospyros virginiana, Quercus velutina, Bumelia lanuginosa, Quercus rubra, Hicoria villosa*, and Crataegus spp. Occurring more rarely are: *Juniperus virginiana, Cercis canadensis, Fraxinus quadrangulata, Robinia pseudoacacia*, and *Sapindus drummondii*. With improving soil conditions this forest type grades into the black oak, hickory association.

3. The Shortleaf Pine, Black Oak, Scrub Oak Association

The *Pinus echinata, Quercus velutina, Q. stellata, Q. marilandica* association is one which is found in more or less isolated areas in sites similar to those supporting the foregoing type. Varying quantities of species of the former association may be found in this pine-hardwood complex. More rarely it is found in small pure stands which are probably largely "old field" areas of one kind or another. Although *Pinus virginiana* and *P. taeda* have been reported as occurring in this region it is doubtful if the former occurs in the state or the latter north of the Arkansas river in western Arkansas.

4. The Black Oak, Hickory Association

The *Quercus velutina, Hicoria villosa* association also ranks high in commonness and extent of area occupied in the region. It occurs on east and west facing slopes, occasional plateaus and less commonly on north or south facing slopes. It is usually associated with soil that is better and less severely drained than of any of the foregoing types. *Quercus velutina* may often make up almost pure stands; more frequently it is associated with various proportions of *Hicoria villosa* and others. Listed in apparent order of diminishing importance are: *Ulmus americana, U. fulva, Quercus stellata, Q. marilandica, Hicoria alba, Ulmus alata, Hicoria buckleyi arkansana, Crataegus* spp., *Diospyros virginiana, Quercus rubra, Cercis canadensis, Fraxinus quadrangulata, F. americana*, and *Sapindus drummondii*. This forest type grades into the white oak, red oak, maple forest with improving site conditions.

5. The Scrub Oak, Elm Association

In some of the few broad, flat valleys of Washington county, *U. fulva,*

Quercus stellata, Ulmus americana, and associates make up the most common forest type present. *Quercus velutina, Q. marilandica, Crataegus* spp., *Celtis* spp., and *Gleditsia triacanthos* and others occur in varying proportions in this association.

6. The White Oak, Red Oak, Red Maple, Hard Maple Hickory Association

The *Quercus alba, Q. borealis maxima, Acer rubrum, A. saccharum, Hicoria ovata* association is the common forest of the north, east and west facing mountain slopes, ravines, gullies or narrow valleys, and less frequently of the deep, narrow south facing gullies or ravines. It also occurs in the bottoms of valleys of small mountain streams. Altogether it is a type that is associated with superior soil and soil moisture conditions, not with excessive but with adequate drainage. A favorable forest site, it is rich in species and variable in composition. Essentially pure stands may occur of *Quercus alba-Acer rubrum-A. saccharum, Quercus alba-Hicoria ovata, Quercus alba-Q. borealis maxima,* or of combinations of any or all of these five species. Other trees occurring in this habitat are listed in groups denoting their apparent commonness.

Very common.

Hicoria alba
Cornus florida
Cercis canadensis
Quercus muehlenbergii
Ulmus americana
Juglans nigra
Ulmus fulva
Ostrya virginiana
Fraxinus americana
Celtis spp.
Quercus velutina
Hicoria cordiformis

Fairly common.

Castanea ozarkensis
Viburnum rufidulum
Quercus macrocarpa
Acer negundo
Carpinus caroliniana
Nyssa sylvatica
Amalanchier canadensis
Morus rubra
Rhamnus spp.
Prunus serotina
Crataegus spp.
Tilia spp.
Asimina triloba

Less common.

Acer leucoderme
Fraxinus pennsylvanica lanceolata
Liquidambar styraciflua
Quercus imbricaria
Juglans cinerea
Cladrastis lutea
Gymnocladus dioicus
Platanus occidentalis
Cotinus americanus
Sassafras variifolium
Gleditsia triacanthos
Fagus grandifolia caroliniana
Magnolia acuminata
Aesculus glabra leucodermis

7. The Soft Maple, Birch, Elm, Sycamore, Cottonwood Association

The *Acer saccharinum, Betula nigra, Ulmus americana, U. fulva, Platanus occidentalis, Populus deltoides virginiana* association is, of course, the type found in the larger stream valleys of the region. It should be borne in mind that this is essentially an upland region and the stream valleys are not wide,

are usually fairly well drained, and are not subject to prolonged submergence at any time of year. Following are other species occurring in this association:

Very common.

Celtis spp.	*Gleditsia triacanthos*
Fraxinus pennsylvanica lanceolata	*Nyssa sylvatica*
Fraxinus americana	*Salix* spp.

Fairly common.

Carpinus caroliniana	*Diospyros virginiana*
Quercus macrocarpa	*Morus rubrum*
Liquidambar styraciflua	*Hicoria cordiformis*
Juglans nigra	*Crataegus* spp.
Acer negundo	

Less common [2]

Hicoria ovata	*Hicoria alba*
Quercus alba	*Asmina triloba*
Quercus muehlenbergii	*Ostrya virginiana*
Quercus borealis maxima	

The Apparent Status of Some Trees of the Region

Following is an hypothetical analysis of the past, present and future standing of some of the species of the forest of northwestern Arkansas. It is based on the assumption that there has been and is operating an east to west migration of forest species, and that there are no features of the zone in question which would positively stop any of the members of this migrating forest.

On the basis of present day range and tolerance to pioneer conditions it seems that *Juniperus virginiana* and *Sapindus drummondii* are two of the older inhabitants of the region. Ocurring rather sparingly in northwestern Arkansas, except in severe sites, their range extends to western Oklahoma or beyond. It is recognized that their present day far-western distribution can be partly attributed to their adaptibility and tolerance and it is by this same token that they may be considered among the early invaders of non-forested Arkansas. *Quercus stellata, Q. marilandica, Ulmus alata* and *Bumelia lanuginosa* are similar to the foregoing species in site adaptiveness but for some reason or reasons occur less constantly west of mid-Oklahoma. Presumably all of the above species have passed their peak and are being replaced by more mesophytic types. *Quercus macrocarpa, Populus deltoides caroliniana, Salix* spp., *Fraxinus* spp., *Acer negundo* and *Ulmus americana* of the more mesophytic associations of northwestern Arkansas extend well into or across Oklahoma. It is understood, of course, that their occurrence is confined largely to river valleys in the western part of the latter state.

The southern shortleaf pine, *Pinus echinata,* is apparently a relict species in this immediate region. Pollen analysis of central Arkansas peat (Sears and Couch, 1932) and of silts from an ancient artificial lake near the Arkansas river in eastern Oklahoma indicate increasing importance of the species in those areas in the last 1000 years or less. However its present limited and discontinuous distribution in the northwestern Ozark region and its relative

2 Species in this sub-group are more apt to occur on steeply sloping river banks or better drained second terraces in the bottoms.

ineffectiveness in competing with deciduous trees suggest a waning species (Turner, 1935).

The described range of *Juglans nigra, Hicoria cordiformis, H. ovata, H. alba, H. buckleyi arkansana, Quercus velutina, Q. rubra, Q. alba, Q. muehlenbergii, Celtis* spp., *Cornus florida, Asimina triloba, Prunus serotina, Amelanchier canadensis, Acer rubrum, A. saccharum, A. negundo* and *Gymnocladus dioicus* extends almost to middle Oklahoma but many of these species are confined to stream valleys, northern slopes, and similarly favorable sites in the western part of this range. Of this group such trees as *Hicoria buckleyi arkansana, Quercus velutina, Celtis* spp. and ecologically equivalent species are of greater importance than the others in this western margin. On the basis of their range and apparent site tolerance members of this general group may be considered an intermediate association preceding the climax by one or more steps. Presumably some species in this group have not yet reached their peak in importance in this region.

Carpinus caroliniana, Ostrya virginiana, Castanea ozarkensis, Quercus borealis maxima, Liquidambar styraciflua, Tilia spp., *Nyssa sylvatica* and *Juglans cinerea* are relatively unimportant west of the Oklahoma-Arkansas line north of the Arkansas river. Apparently *Magnolia acuminata* and *Fagus grandifolia caroliniana* do not occur within 50 miles of the state line in this region. If what is understood to be the normal sequence of events in forest succession is actually occurring here, members of this group should be considered relatively recent invaders and destined to constitute the climax forest of the region. With undisturbed conditions it might be anticipated that out of this group and the foregoing such species as *Acer saccharum, Quercus alba, Q. muehlenbergii, Q. borealis maxima, Tilia* spp., and possibly *Fagus grandifolia caroliniana* would attain more prominence than they now possess. However, because of the constant cutting, fires and grazing it would be very difficult and hazardous to predict the character of ensuing forest migration and succession.

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NEW AND UNCOMMON PLANTS OF ILLINOIS AND WISCONSIN

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The great drought of last summer over the Mid-continent included the Chicago region and part of Wisconsin. Its biological and morphological effects were far-reaching, but from the plant collector's viewpoint it was a "poor harvest" as much as for the farmer and his dependents. I saw the season through, but those of my notes bearing on taxonomy are but few. While most species common to our region were greatly discouraged, those more at home on the western plains, fringing their range or adventitious here did exceptionally well, as might be expected. Besides, a favorable fall, humid and with frosts long delayed, produced a luxuriant show of the late Compositae, especially of the genus *Aster*. In all my experience I never before saw such a magnificent display of these in masses of white and blue—one riot of color in the landscape.

Of the more unusual plants met with during the season may be mentioned:

Juncus alpinus Vill. var. *insignis* Fries. Near Lake Como, Walworth County, Wisconsin it may be found in masses of considerable extent. About Wonder Lake, McHenry County, Illinois, *Cyperus filiculmis* Vahl is a common sedge but the plants have but a single head, none with auxiliary heads could be found, nor any of the var. *macilentus* Fernald.

Around Algonquin, McHenry County[1] much darnel has found its way into the fields. It is worthy of note that it is not all the usual *Lolium perenne* L., but a large percentage is of the few-flowered, bearded species, *L. italicum* R. Br., but no plants of *L. multiflorum* Lam. were seen.

About Ringwood, McHenry County, Illinois, were found large colonies of *Atriplex patula* L. var. *hastata* (L.) Gray of luxuriant growth with branches a meter or more in length—in view of the dry season, surprising. Along tracks and roadways just west of the grounds of A Century of Progress much *Kochia Scoparia* (L.) Schrad. had established itself—a plant usually seen only in cultivation or as a waif about dumps. Here it had become weedy and crowded out other growth for considerable stretches, a striking change from previous years.

Chenopodium Standleyanum Aellen *(C. Boscianum* Moq. *ex parte)* which was taken in Indiana before, was now seen near Ringwood, and near the Wisconsin state line.

It was a genuine surprise to meet with *Ajuga genevensis* L., perhaps escaped but well established by the roadside in Palatine, Cook County.

[1] Where no state is mentioned in this article, Illinois is understood, and the county in connection with localities is given but once except in connection with diagnoses of new varieties or forms.

Algonquin nestles in the beautiful valley of the Fox River, surrounded with high morainic hills. On some of these was found flourishing in large patches, *Lespedeza capitata* Michx., and with it almost to the extent of one-half the total number of plants but in separate colonies, its var. *velutina* (Bicknell) Fernald. In the field, these latter plants with their silvery foliage appear in striking contrast from the species which turn their green upper surfaces to view.

Carum Carui L. is still cultivated, though much less than formerly in the valley of the Fox. Though infrequently, it escapes at times. About the village of Fox River Grove, many plants were seen running perfectly wild in the edges of woods and by the roadside.

Pycnanthemum flexuosum (Walt.) BSP. which occurs in fields of con siderable extent in this region at times, commonly has white corollas—exclusive of the purple dots. About Mount Prospect, Cook County, the corollas are generally shaded in bluish, purplish or lilac, at times very decidedly, but since intermediate shades are much in evidence, no color form can well be separated.

Solanum Dulcamara L. f. *albiflorum* House was an aberration from the usual color of the species at Fox River Grove. Another case was that of *Cirsium arvense* (L.) Scop. f. *albiflorum* R. Hoffm. (1922, House id. 1923).[2] Though Canada thistle, so much detested on the farm is locally common, the white-flowered form is quite rare.

Along streams, ditches and other low ground the *terrain* is often beautified by assemblages of *Physostegia virginiana* (L.) Benth. It is conspicuous by reason of its large-flowered spikes of rose to bluish purple. I never came upon a white-flowered form till the past summer when a small cluster of them stood out prominently in a field of rose-purple. With no intermediate shades in evidence it may be designated:

Physostegia virginiana (L.) Benth. f. **candida** f. nov.

A forma typica corolla alba differt; forma rara.

With the species; corolla white; rare form.

ILLINOIS: Arlington Heights, Cook County, August 25, 1934. *H. C. Benke* 5681 (Type in Field Museum).

This species having flowers so attractive is popular with horticulturists who frequently take them out of the fields for garden development. Various shades in races have thus been produced, it being their ambition to secure novelty in beauty and variety. Delicate shades to pure white have thus come to my notice which are known under various names, most commonly as rubra for red and alba for white-flowering variations. Like many others, when taken from their native habitat, they undergo striking changes in the garden—much wider leaf-form, strong inflation of the calyx, etc.

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2 Hoffman, R., Proc. Boston Soc. Nat. Hist. **36**:340, 1922, and House, H. D., Bull. N. Y. State Museum **243-244**:22, 1923.

The genus *Aster* yielded some plants which are still being studied by myself and others. *Aster Drummondii* Lindl. var. *rhodactes* Benke,[3] first published from Justice Park, Cook County, was again found in good quantity (several meters in extent), some 30 Km. to the north near Dee Road, a new railway station in Cook County. Near Crystal Lake, McHenry County were found considerable masses of *A. ericoides* L. with very dense inflorescence crowded on short ascending branches, oval or orbicular in outline, terminal on the plants. Another unusual habit of growth was noted in a fine body of *A. sagittifolius* Wedemeyer near Algonquin. The plants all were tall, to 1.5 m. in height with short branches of long, narrow inflorescence. Distinctive plants of *A. pilosus* Willd. var. *platyphyllus* (Torr. & Gray) Blake[4] seem to be infrequent in Cook County, but specimens were taken at Berkley. They are quite common about Elgin, to the south-west in Kane County.

Fields of alfalfa, cultivated and escapes, have frequently come to my notice during my travels in various states. When in bloom the solid sheets of blue and purple-blue in various shades and tintings are a gladsome sight. During the past season, a particular field of vigorous growth even spreading to the roadside, to the north of McHenry in which some patches of cream-yellow and a couple of smaller ones of pure white were conspicuous, attracted my attention and was kept under observation while in flower. They grew mostly towards the edge of the field and roadway where they appeared to be well established. Careful records were made and a liberal number of specimens were taken.

In looking over quantities of herbarium material, it seems to be a rather common practice to consign any yellow-flowering alfalfa specimen to *Medicago falcata* L., or treat it as a hybrid of this species with *M. sativa* L.—holding true in cases, of course. White-flowered herbarium specimens have not been available for my inspection as notes on coloration are usually absent. These must be made in the field as in the case of most Leguminosae because of their ephemeral nature after collecting. That a plant, known for so many centuries, particularly in the Old World, having been the subject of so much study and research should not have been treated by taxonomists in all its forms seems rather strange, hence it is with some trepidation that one undertakes to announce a new form here. After having examined much literature, old and new including European, it seems as though the recording of the white-flowering form has been overlooked and should be published:

Medicago sativa L. **f. alba** f. nov.

A form typica non nisi corolla alba differt; a *M. falcata* L. var. *albiflora* Babey, *(M. macrocarpa* Urban f. *albiflora* [Babey ex Rouy et Faucaud] Urban) foliolis latioribus, fructibus non lunulatis, caulibus fere erectis glabris distinguitur; forma rarissima.

3 Benke, Rhodora **31**:151, 1929.
4 Blake, Rhodora **32**:139, 1930.

With the species, except color of corolla which is pure white; not with *M. falcata* L. var. *albiflora* Babey *(M. macrocarpa*[5] Urban f. *albiflora* [Babey *ex* Rouy *et* Faucaud] Urban),[6] differing in size and shape of leaves; pods, pubescent and not lunulate, but plainly spiral; stem quite erect, glabrous; form very rare.[7] Hybridism not suspected.

ILLINOIS: McHenry, McHenry County, Sept. 11, 1934. *H. C. Benke* 5665 (Type in Field Museum).

The cream or pale yellow-flowering plants, also rare in this field, yet were five or six times as numerous and in larger clusters than the pure white ones. Although a vast amount of work has been done with *Medicago,* including the yellow-flowering plants, yet by further study in the field, it is possible that a hitherto undescribed variety or form may here be disclosed.

Making due allowances for variability in characters within conservative limits,[8] they key down to *M. varia* Martyn f. *pallida* (Alef.) Rouy (or, Rouy et Faucaud?) *ex descr.;* not *M. varia f. erectiuscula* Rouy *et* Faucaud (=*flavicans* Borbas), the latter with glabrous fruit, lunulate pod, etc. Most varieties or forms of *M. varia* have mule corollas of changeable or mixed colors during anthesis, not applicable to my specimens. *M. varia* can be treated as a variety of *M. sativa* in Urban's subsp. of *macrocarpa* (var. *varia* [Martyn] Urban. My plant does not aberrate from Linnaeus' *M. sativa,* except in color of the flowers, hence it does not agree with *M. falcata* L. var. *aureiflora* Babey *ex* Rouy *et* Faucaud,[9] with deep yellow to orange corollas and other decisive qualities out of harmony.

Through the courtesy of Carl Colby, an enthusiastic friend and painstaking student for many years of the flora of the region about his home at Pittsville, Wisconsin, a number of uncommon plants were received. Among *Rubus* were some fine specimens of *R. hispidus* L. forma *pleniflorus* Nieuwl. His collection of *Aster puniceus* L. with carefully recorded notes represents an interesting series of varieties and color forms from white and pale blue and lilac to deep blue, purple and rose. Outstanding among these, is *A. puniceus* L. var. *albiflorus* Farwell, and a number with beautiful deep rose-red rays, which do not appear as of record, so feel justified in naming them for their collector, as:

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5 Subspecies.

6 Urban suspects hybridism by some intermediate characters—*M. sativa* with *M. falcata.*

7 Hegi, G., Ill. Flora von Mittel-Europa, **4**(3): 1259. ". . . . sehr selten weiss."

8 Ascherson und Graebner, Syn. der Mitteleuropäischen Flora **6**(2):398. ". . .sehr veränderlich"; and Hegi, G., Flora von Mittel-Europa, **4**(3):l.c. ". . . . ist sehr veränderlich; es ist jedoch schwer besondere Rassen auszuscheiden."

9 Or treatment by Urban in *macrocarpa* subsp. (sp. by Moris).

Aster puniceus L. var. **Colbyi** var. nov.

Capitula pauca; bracteis, exterioribus viridibus, interioribus dorso viridibus, omnibus subaequalibus, acutis atque acuminatis; folia elongata, angusta, caulina circa 1cm. lata, 8cm. longa, minus hispida quam in forma typica; ligulae roseo-rubrae.

Heads rather few; bracts outside typical green, inside green down the back, all subequal, acute and acuminate; leaves rather long and narrow, cauline averaging about 1cm. x 8cm., less hispid than species; rays rose-red.

WISCONSIN: Pittsville, Wood County, Sept. 7, 1934. *Carl Colby* 5715 (Type in Field Museum).

Specimens of all plants named in this article have been deposited in Field Museum of Natural History Herbarium, Chicago, Illinois.

CHICAGO, ILLINOIS.

Notes and Discussion

SOME ASTERIAFORM FOSSILS FROM THE FRANCIS FORMATION OF OKLAHOMA

DAN J. JONES

During a field trip into the Arbuckle Mountain area in 1932, eleven individual asteriaform fossils were found on a single slab of sandstone, from an outcrop of the upper Francis formation near Seminole, Oklahoma.

The Pennsylvania Francis formation outcrops near the town of Fitshugh, in Pontotoc county, on the north slope of the Arbuckle Mountains, and trends northeastward across Pontotoc, Seminole, and Okfuskee counties. Lithologically, it consists of a series of blue and black shales, with thin sandstones and limestones, totaling 500 feet.[1] Of this, the upper 100 feet are a series of shales and brown sandstones. It is from a thin sandstone in the upper ten feet of the Francis that these fossils occur. Following is a list of characteristic fossils, after Gould and Decker[2]:

Lophophyllum profundum	*Marginifera splendens*
Fistulipora sutulis	*Euphemus carbonarius*
Polypora elliptica	*Naticopsis altonensis*
Chonetes granulifer	*Worthensia tabulata*
Derbya crassa	*Orthoceras tuba*
Dielasma bovidens	*Phillipsia major*

This generalized faunal list indicates a marine habitat.

Fig. 1. Asteriaform fossils from the Francis formation. x 0.25.

1 Morgan, Geo. D., Okla. Bureau Geology Bull. **2**: 113-119, 1924.

2 Gould, C. N., and Decker, C. E., Okla. Geol. Survey Bull. **35**:48, 1925.

The specimens consist of sandstone casts from original molds. They are fairly uniform in size, as may be seen from the following measurements of the ten most complete specimens:

NO.	HEIGHT	WIDTH	NO.	HEIGHT	WIDTH
1	14 mm.	13 mm.	6	11.0 mm.	10.5 mm.
2	12 mm.	— mm.	7	13.0 mm.	12.0 mm.
3	18.5 mm.	18.6 mm.	8	14.0 mm.	14.5 mm.
4	16.5 mm.	15.5 mm.	9	15.0 mm.	13.5 mm.
5	12.5 mm.	13.0 mm.	10	8.5 mm.	6.3 mm.

Specimens 1, 3, 6, and 10 do not appear to have been distorted from their original shape, while the arms of the others seem to have been disturbed or moved from their original pentagonal pattern. This seems to eliminate the slight possibility that they are inorganic. On specimens 1, 3, 4, and 8 there occurs, on the central disc-area, a small, pit-like structure that may correspond in shape and position to the madreporite of a starfish. Specimen no. 3 is the most perfect, its rays extending from the center at subequal angles of 70 degrees. In specimen no. 8 the arms are not as slender, but shorter, wider, and more blunt. The central depression is larger, and is in almost the exact center of the disc, and not excentric, as in the others.

These characters strongly suggest that the fossils are small or young starfish. It is possible, however, that they are related to the problematical *Heliophycus*, a "plant" fossil, described by Miller and Dyer.[3] It, however, is hollow, and possesses numerous transverse wrinkles, which are not present on the fossils under consideration. Also, *Heliophycus stelliforme* is much larger than that of the forms from the Francis.

It is significant that on another piece of sandstone from the same horizon were found numerous worm borrows, and deep, wide, wave ripple-marks, suggesting that the water in which the sediment was deposited was shallow.

This is, to the knowledge of the author, the first occurrence of either Pennsylvanian starfish or Pennsylvanian asteriaform "algal" colonies in the state of Oklahoma.

3 Miller, S. A., and Dyer, C. B., Contr. to Paleon. no. **2**, pl. 3, fig. 3, 1878.

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Book Reviews

GYMNOSPERMS: Structure and Evolution. by Charles J. Chamberlain. University of Chicago Press. 1935. viii + 484 pp., 397 figs. $4.50.

To those who have had the pleasure and opportunity of studying under Professor Chamberlain, this book has a very familiar tone. In it are expressed the opinions and points of view concerning the structures and phylogeny of the Gymnosperms which the author has discussed with his classes for a good many student generations. It is not an editor's compilation; much detail has necessarily been omitted, particularly in those chapters dealing with fossil groups *(Cycadofilicales, Bennettitales, Cordaitales)*. It is, on the contrary, the thesis of one, who after a lifetime of diligent study, states his personal convictions and opinions as convincingly as possible. Consequently this book must take its place among those rare volumes which represent the peak of scholarly writing—the drawing of conclusions in a chosen field by a man of authority.

The organization of the 21 chapters reflects the author's view that the seven orders of the Gymnosperms are grouped into two main phylogenetic lines which have been distinct at least from the Carboniferous onward. These two lines are designated as the Cycadophytes *(Cycadofilicales, Bennettitales, Cycadales)*, characterized by being comparatively small and with unbranched stems bearing pinnate leaves, the stems in section having a large pith, scanty wood and thick cortex; and the Coniferophytes *(Cordaitales, Ginkgoales, Coniferales, Gnetales)*, large, profusely branching with simple leaves, the stem in section having a small pith, abundant wood and scanty cortex.

The chapter devoted to the *Cycadofilicales* treats the material conventionally, giving the life-cycle in so far as known of *Lyginopteris, Heterangium* and *Medullosa*. This is not a chapter for systematic paleobotanists. But the section dealing with phylogeny gives the author an opportunity to develop excellently and at length his conception of the origin of the *Cycadofilicales*. He states, "The genetic line must have been homosporous Filicales, heterosporous Filicales, Cycadofilicales" (p. 40); and again, "We believe it to be a fundamental of development that homospory must percede heterospory, and that the heterosporous Pteridophyte condition must precede the seed condition" (p. 32). In other words the *Cyadofilicales* must have arisen from some heterosporous Pteridophyte by direct descent. A series of illustrations suggests the hypothetical development of a heterosporous Carboniferous fern-ancestor of the *Cycadofilicales* and the development of a megasporangium after it has passed the fern stage and has become a structure of a seed plant *(Cycadofilicales)*. The distinction between the two is based on the usual *arbitrary* distinction between seed and non-seed plants, that is the *permanent* retention of the megaspore within the megasporangium in seed plants.

The *Cycadales* and *Bennettitales* are considered as representing independent lines originating from the *Cycadofilicales*. Because of the differences in the strobilus, the author believes it to be impossible to derive the *Cycadales* from the *Bennettitales*, a point of view suggested by Professor Wieland, the eminent authority on "Fossil Cycads," as early as 1901. The single terminal ovule of the *Bennettitales* and the lateral ovules of the *Cycadales* megasporophyll could each be derived from a member of the *Cycadofilicales* of the *Neuropteris* type which bore both terminal and lateral ovules. The loss of the lateral ovules could give rise to the *Bennettitales* type; the loss of the terminal ovule could give rise to the *Cycadales* type.

As to the possible origin of Angiosperms from the *Bennettitales*, Professor Chamberlain says (p. 59), "That the Bennettitales may have given rise to any of the Angiosperms we regard as not only improbable but impossible." Later, "they (Bennettitales) left no progeny." In view of the repeated attempts to derive the Angiosperm flower from the *Bennettitales* strobilus, it is unfortunate that space did not allow the author to give a more detailed discussion of this problem.

Almost a fourth of the text is given over to a consideration of the *Cycadales*.

This is unquestionably the most complete and detailed account of this order of plants available. A short but interesting account of cycad "hybrids" is included.

A short chapter of 15 pages concludes the account of the extinct order of *Cordaitales*. Here, again, the paleobotanist may be disappointed at the conventional treatment of the material. The account does emphasize, however, that although more recent investigations may have added to our knowledge of the organization of the wood, almost nothing has been added to our knowledge of the life-history of this order since the classic investigations of Grand d'Eury and Renault, over half a century ago.

The *Cordaitales*, Paleozoic representatives of the Coniferophyte series, existed side by side with the *Cycadofilicales*. The *Cordaitales* most probably arose from some heterosporous Paleozoic Pterodophyte, possibly, though not necessarily, from a different section from that which gave rise to the *Cycadofilicales*. Professor Chamberlain considers that the *Coniferales* have arisen from the *Cordaitales;* probably the *Ginkgoales* also, although the possibility of a common origin of the *Cordaitales* and *Ginkgoales* is reviewed.

The largest section of the book is devoted to the *Coniferales*. The terms *Pinares* and *Taxares* employed by Buchholz are adopted. The *Pinares* include the families *Abietaceae*, *Taxodiaceae*, *Cupressaceae* and *Araucariaceae*, together with any splitting of these families; the *Taxares* include the *Podocarpaceae* and *Taxaceae* with any possibly derived groups. The perennial problem of the interpretation of the ovulate strobilus is reviewed. The author is not convinced that the proponents of the "flower" interpretation of the strobilus have offered satisfactory evidence, and prefers to consider the ovuliferous scale as a modified shoot which bears the ovules, the cone being compound and therefore not a flower but an inflorescence.

Three chapters discussing the *Gnetales* bring together a rather complete account of the known structure and reproduction of this order. Concerning the phylogeny of the group the author says (p. 362), "They are Gymnosperms because they are seed plants with naked ovules, and *Ephedra*, carrying the other two genera *(Gnetum* and *Welwitschia)* with it, has a Gymnosperm life-history. Otherwise the whole assemblage would be an isolated group, without even a problematical relationship."

The final chapter discusses "Alternation of Generations." The author's views are summarized in this paragraph (p. 445); "Alternation of generations, viewed as an alternation of x and 2x phases in the life-history, is strictly antithetic. Since we believe that alternation of generations arose from the fusion of gametes, the resulting zygote being the first cell from which the evolution of the sporophyte began, we see no place for the old theory of homologous alternation, especially since it was based largely upon the phenomena of apogamy and apospory, which are merely abnormal digressions from the normal life-history," and (p. 442), "The zygote is the first cell of the 2x generation, whether it divides many times, building up a more or less extensive 2x body, or does not divide at all. The zygote, even in Spirogyra might be called a sporophyte."

In a work of this scope it is manifestly impossible to develop all topics completely. It would appear, however, that the space devoted to the consideration of the *Caytoniales* is all too little. With the exception of certain Devonian spore-bearing plants ,no report of extinct plants in recent years has occasioned as much discussion, nor has been of such potential importance as that of the *Caytoniales*, regardless of the final taxonomic position of the group, whether Gymnosperm, Angiosperm, or *both*, as Professor Thomas has recently suggested informally. A number of papers no doubt could not be discussed because of their recent appearance. Among these might be listed Florin's important papers on stomatal types in Gymnosperms, Hagerup's analysis of *Juniperus;* papers by Hörhammer, Lanfer, Slyper, of fairly recent date are not listed in the bibliography of 718 titles, nor is von Goebel's third edition (1933) of his *Organographie der Pflanzen*.

These references but emphasize the magnitude of the task of preparing a comprehensive treatise of so extensive a group as Gymnosperms.

A review of this volume cannot be complete without commenting on two other features. Few books include as careful a selection of illustrative material, both as to

pertinency and reproductive qualities. A large number of the 397 figures are new. Many others have been prepared and previously published by the author. There are not less than 90 half-tones, which give an excellent photographic display of living Gymnosperms. And in addition, Professor Chamberlain's style of exposition is one which students may well study. It is personal, informal, vividly clear, without the least sacrifice of scientific accuracy or brevity. An inexperienced student may read with understanding; an experienced student with profit.—J. H. HOSKINS.

THE STRUCTURE AND REPRODUCTION OF THE ALGAE. I, by F. E. Fritsch. New York: Macmillan Co., 1935, xvii + 791 pp., 245 figs. $8.00.

This is the first comprehensive treatment of the morphology of the Algae in the English language. The author has used the term "alga" in the widest sense, including all of the holophytic Protista and their immediate non-holophytic allies. An attempt has been made to cite all of the literature appearing since 1890, excepting only those which appear not to be of consequence in relation to the subject matter. Important papers appearing before 1890 have been included.

Eleven classes of Algae are recognized, of which eight are considered in volume I. These are treated in the following order: *Chlorophyceae (Isokontae), Xanthophyceae (Heterokontae), Cryptophyceae, Dinophyceae (Peridineae), Chloromonadineae, Euglenineae, Phaeophyceae, Rhodophyceae, Myxophyceae (Cyanophyceae).* The termination "phyceae" has been adopted wherever the class includes forms with an algal organization, while for those classes *(Chloromonadineae, Euglenineae)* in which none such are known, the old flagellate designation is retained. While the author refers to the grouping of certain of these classes into Divisions *(Chrysophyta, Pyrrhophyta,* etc.) he prefers to consider each of the eleven classes as a separate evolutionary series until a clear relation to the others is indubitably established. The difficult problem concerning the taxonomic position of the various algal groups as regards the plant kingdom as a whole is not considered in this first part. It is to be hoped that the question will be discussed at length in the second volume.

An introduction of 54 pages contains a discussion of many fundamental topics. Some of these are: the relationship between algae and flagellata; the broad classification of the algae; the special features of the algal cll; the general course of reproduction in the algae. In this latter connection the author contrasts *isomorphic (homologous)* alternation of generations as exhibited by *Zanardinia* and some of the *Cladophoraceae,* with a *heteromorphic (antithetic)* alternation such as is exhibited by *Cutleria* and the *Laminariales.* A foot-note calls attention to the fact that Continental workers often refer to the former type *(isomorphic)* as *antithetic,* which the author considers incorrect. If the nuclear phase changes are fundamental in the establishment of an alternation of generations, then the isomorphic or heteromorphic character of the thallus resulting from the fertilized egg and from the spore becomes of secondary importance to the *x* or *2x* character of the thallus. Consequently the alternation of generations in *Zanardinia* or *Dictyota* would be as truly *antithetic* as in *Laminaria,* a view held by many American as well as Continental botanists.

It is interesting to note that both the *Charales* and *Conjugales* are included as orders in the *Chlorophyceae.* Concerning the *Charales* the author states (p. 466), "The occurrence of green chloroplasts and starch, the haploid character and the relatively simple vegetative organization of the Nitelleae, all speak for the Charales as representing merely a very highly specialized side-line of the Chlorophyceae". This view becomes more acceptable if Goebel's ingenious explanation of the antheridium of the *Characeae* is accepted, in which case the antheridium is merely a single-celled structure like those of most other algae. In regard to the systematic position of the *Conjugales* the author writes (p. 361), "Many authors have sharply separated the Conjugales from the other green algae, but for this is no warrant. They do not show more outstanding peculiarities than the Oedogoniales or Siphonales, and the absence of

motile reproductive stages, on which much stress has been laid, is a feature which occurs widely in the Chlorococcales. On the other hand in their metabolism they agree altogether with other green algae".

This important work of an outstanding autority is most timely, appearing when a renewed interest in the study of algae is quite apparent. Both the research and general student of algae will find it necessary to add this publication to their libraries. Volume II will be awaited with interest.—J. H. HOSKINS.

MANUAL OF DRAWING FOR SCIENCE STUDENTS, by Justus F. Mueller. New York: Farrar and Rinehart, Inc., 1934. xiii + 122 pp. $1.75.

The first five chapters of this book state elementary principles of drawing which are most important to the scientist and science student, whether he is preparing sketches for a notebook or copy for publication. Statements are simple yet clear; figures are aptly illustrative of both principles and methods, those illustrating projection and lighting being specially good. With the optical and mechanical aids summarized in Chapter VI, they should vastly improve the quality of most scientific illustration.

Chapter VII, on drawing for reproduction, is less satisfactory. Dr. Mueller limits himself to biology, though casual examination of such a journal as the *Geological Magazine* must have shown him that scientists in other fields stand in equal need of instruction. In part they may apply technique outlined by Dr. Mueller, but a few more specific helps (on irregular masses, physiographic diagrams, block sections, etc.) would add much to the usefulness of the book. The emphasis on values of simplicity is apt. — especially when a number of paleontologic authors stress the desirability of "untouched" photographs, avoiding drawings in all possible cases.

Dr. Mueller over-emphasizes the difficulty of wash drawings, and fails to mention the excellent results to be achieved by wax pencils such as Dixon's Thin-ex 379 or Faber Ebony 6325, used on smooth bristol board. Done on large scale, for half or more reduction, they give results comparable to ink wash. Such pencils also may be combined advantageously with ink wash.

Instructions for assembling copy, and samples on pages 112-113, apparently assume that all halftones will be routed. This, of course, may be avoided by making outlines in advance and so spacing them that they may be drawn in place.—C. L. FENTON.